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APPLIED MECHANICS REVIEWS

VOL. 11, NO. 8 MARTIN GOLAND *Editor* AUGUST 1958

MECHANICS OF VEHICLE MOBILITY IN OFF-THE-ROAD LOCOMOTION

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It may be interesting to note that the mechanics of highway locomotion was never treated as a whole despite the popularization of the automobile. Particular problems emerging from time to time were solved mainly in a piecemeal approach, and most of the serious theoretical work appears to be dispersed in unrelated sources. No single volume encompasses the variety of subjects from Lehr's fundamental study of vehicle vibrations (1) to the dynamic stability of the whole vehicle as discussed by Milliken, Segel, Withcomb and others (2) or from a "topological" discussion of the price of speed by Gabrielli and von Kármán (3) to the morphology of a vehicle by Neesen (4).

To expect the accomplishment of such a task now would be perhaps premature, as many links which would eventually tie various topics into one whole appear to be still missing. A typical example, for instance, is the still lacking development of a comprehensive mechanics of the pneumatic tire, which may be seen in the review of the state of the art in this field by Hadekel (5).

Perhaps the automobile does not need generalizations of this type as its future is often seen in the development of highways and automation of controls and traffic rather than in any radical change of the vehicle itself.

Such an outcome, if real, would completely parallel the development of railroads. However, in off-the-road locomotion this analogy does not hold, and the lack of theoretical approach to the subject appears to have hampered the progress (6). This already has called for systematic general solutions which would embrace the totality of problems in the soil-vehicle relationship because the great variety of environmental conditions does not allow treatment of each case separately.

The problem looked upon in this way appears to be enormous (6) (7). Its practical and speedy solution apparently could not be sought in idealized conditions of the rolling friction such as assumed in the classical treatment of perfectly elastic materials of the wheel and the road (8), or rigid wheel and viscous road (9), but had to start with Reynolds' studies of rolling various cylinders on various surfaces (10) to which the most recent contribution by Drucker has added a final touch by considering wheels in plastic soils (11).

The present preoccupation of engineers and scholars with such a seemingly simple phenomenon as the motion of a wheel on a soft ground is not new. Its beginnings may be dated back to Coulomb, Grandvoinet (6), and Morin (12). The problem was further investigated at the beginning of the present century by Bernstein, Gerstner, Schultz, Goriatchkin, Letoshnev, Kühne, Mayer, Swieżawski, Kanafojski, Halkinov, and McKibben (6).

The results were expressed either in the form of empirical data or led to attempts of solutions based on static conditions of equilibrium within the assumed forces and moments. Swieżawski's attempts of generalization of the problem appear of particular interest (13). However, Bernstein's solution (14) has brought more implications and will be discussed later.

No comparable work existed in the field of crawler-type vehicles until the late twenties, although a tracked vehicle was invented by Edgeworth in 1776. General studies in that respect, which contain some notions of soil-vehicle relationship, were published by Zaslawski (15), and Kristi (16).

However, not until the outbreak of World War II was it possible to base soil-vehicle study on well-established principles of soil mechanics. It was Micklethwait who first proposed to link the ability of a vehicle to cross a soft soil with the bearing capacity of the ground, and the thrust with soil shear (18). Micklethwait proposed that a solution of these two problems may be based on the Prandtl-Terzaghi solution of the failure of plastic masses and on the Coulomb-Mohr criterion of soil failure (19). Most recently, Payne has adopted the same principles in his evaluation of relationship between soils and agricultural machinery (20).

Practical weakness of the above approach is noted in the lack of a definition of stress-strain functions in actual soils. Bernstein assumed that vertical ground deformation z under unit load p may be expressed by equation $p = k\sqrt{z}$ (14); the Russian engineers generalized the relationship in the form $p = kz^n$ (where k and n are the assumed soil parameters) (17). However, the solutions thus obtained could not be generalized, for it was known that k is not a modulus of soil deformation but rather a variable depending on the size and form of the loading area.

The writer, following this line of thought (21) and subsequently attempting to generalize the functions of load-deformation, for practical purposes, proposed the following equation for the case of vertical deformation of soil (vehicle sinkage):

$$p = (k_c/b + k_\phi)\, z^n$$

where "moduli" k_c and k_ϕ, as experiments have shown, are practically independent of the size and form of the loading area if the initial, insignificant elastic deformation of soft

soil is neglected (22). For $n = 1$ the equation reduces itself to a form well known in soil mechanics. b is the smaller dimension (width) of the loading area.

In the case of horizontal deformation such as vehicle slippage the shear of the soil shows a pattern different from that in sinkage. This led the writer to propose the following function:

$$r = \{(c + p \tan \phi)/Y_{max}\} \{\exp[(-K_2 + \sqrt{K_2^2 - 1})\, K_1 j] - \exp[(-K_2 - \sqrt{K_2^2 - 1})\, K_1 j]\}$$

where unit soil thrust r is defined by soil parameters K_1, K_2, and soil deformation j which is directly related to the percentage of vehicle slip. Y_{max} is the maximum of the function enclosed in the second pair of brackets $\{\ \}$. c and ϕ are Coulombian cohesion and friction, while p is the ground pressure (22) (23) (6).

The above equation for optimum slippage reduces itself to Coulomb's formula $r = c + p \tan \phi$ which Micklethwait originally proposed in vehicle evaluation (18).

With the above semi-empirical measures of ground strength and deformation it became possible to plan a general outline of the mechanics of land locomotion which was discussed at a number of conferences and seminars (24). The general scope of such a mechanics, the nature of problems, possible methods of attack, implications, and potentialities have been discussed elsewhere (6).

The latest development in this field has embraced experimental verification of a number of mathematical models pertaining to the motion and efficiency of wheels, tracks, and complete vehicles. The approximate character of solutions obtained and a need for further work are obvious (25). However, some conclusions of a general nature appear quite unquestionable.

It results from the previously discussed Coulomb's equation, which may be assumed in a first approximation as a measure of thrust of conventional vehicles, that the thrust/load ratio is expressible in the form $r/p = c/p + \tan \phi$. This would indicate that the present design trend, which is implicit in that equation, has reached the end of its evolution. For, the unit thrust of a land vehicle cannot be further increased without reducing ground pressure.

This reduction has been the objective of all vehicular developments in the world for the past decades and since it has reached fixed limits which have remained unchanged for at least 25 years, there seems to be little hope, if any, for a radical improvement of thrust. The present writer has shown, however, that progress may be achieved through a radical change of vehicle forms which leads to what may be called "train concept" of a land vehicle (6) or the "articulation" of land vehicles by building them in two or more units which can pivot when steering around their joints (6) (21) (34).

Another apparent need for a change of track and wheel form also became clear in the light of the recent soil-vehicle evaluation.

A study of individual track cleats led to the development of a theory (21) based on the properly modified Prandtl-Terzaghi solution of bearing capacity for two-dimensional footings, which accommodates both vertical (weight) and horizontal (thrust) loads. The three-dimensional solution was based on a method similar to that which Rathje (26) and Buchholtz (27) used in the evaluation of soil shear by blunt bodies and anchors. A novel photographic method of exploration of the extent of Rankine and radial shear zones generated by a track cleat in the ground was applied in order to obtain results of direct practical value (21) (28).

The theory and experiment showed distinct advantages in the wide spacing of track cleats instead of mounting them close together as has been done in the case of conventional tracks (21) (29). The improved results were theoretically deduced from the equation of thrust r as developed by the new track:

$$r = (c\, s\, n_c + \gamma\, s^2 n_\gamma) \sin \theta$$

where n_c and n_γ are modified Terzaghi bearing-capacity factors (19). These factors were computed and tabulated in reference (21). γ is soil density and s is the length of the cleat; $\theta = \tan^{-1}(r/p)$ (see ref. 21). Tests performed with experimental vehicles and laboratory studies are quoted in a confirmation of the expectations (21) (29).

An application to the wheel problem of the previously quoted thrust-slippage equation, $r = f(c\phi\ K_1\ K_2\ j)$, revealed not only the importance of the form of the ground contact area but also that of the orientation of the area with reference to the direction of motion (6). This revelation has indicated a necessity for a basic change of present tire forms for soft ground operations (6) (23).

In general, the work so far performed seems to indicate that a radical change in morphology of off-the-road vehicles will be required to make the maximum use of the purely engineering improvement of vehicle elements (6).

In pursuing that goal it has also been noted that the effect of ground surface roughness may slow locomotion even to a standstill because of inciting intolerable roll and pitching (6). This necessitated the undertaking of studies on power spectrum of random terrain "waves" and an analysis of vehicle response which, in a sense, is similar to the approach developed by naval architects in a study of ship motion in a confused sea (31). Design of special equipment for analyzing the geometry of soil surfaces is under study (30).

Since testing of various mathematical models of vehicle performance and behavior by means of full-size vehicles is not always possible, desirable, or convenient, small-scale model testing techniques similar in concept to testing aircraft in wind tunnels or ships in towing tanks have been developed. Preliminary work by Nuttall based on dimensional analysis was preceded by a small number of other investigations and led to a certain clarification of the problem (6). However, it appears clear that much remains to be done in this area before fully satisfactory results are obtained. The increased cost and time element of full-size tests stress the necessity for the continuation of such work. Small-scale model testing based on analytically defined similarities has shown more general and immediate promise (6).

The recent interest displayed in the discussed field (32) appears to indicate that both the universities and industry may accelerate the development of land-locomotion mechanics in the near future.

One may wish that the future activities embrace a rational analysis of complete soil-vehicle systems in which the definition of mobility is based on a suboptimization of operational values (33), and that the study of static equilibria of a soil-vehicle system will be supplemented by the analyses of dynamic steady states or transients, whenever possible.

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Theoretical and Experimental Methods

(See also Revs. 2924, 2947, 2961, 2976, 2979, 3022, 3025, 3048, 3071, 3141, 3145, 3150, 3172, 3195, 3340)

Book—2914. Kamke, E., Differential equations of real functions [Differentialgleichungen Reeller Funktionen], Leipzig, Akademische Verlagsgesellschaft, 1956, xiv + 442 pp.

This third edition of the well-known treatise by Professor E. Kamke gives a systematic and up-to-date survey of the theory of the differential equations of real functions. The book is divided in two parts. The first part deals with ordinary differential equations whereas the second part deals with partial differential equations of the first and second order.

The material in the book is presented in a very clear and lucid manner and with mathematical rigor. Many well-chosen examples illustrate the chapters. E. Volterra, USA

2915. Aizerman, M. A., and Gantmakher, F. R., Determination of periodic regimes in a nonlinear dynamic system with piecewise-linear characteristics (in Russian), *Prikl. Mat. Mekh.* **20**, 5, 639–654, Sept.-Oct. 1956.

Periodic solution of a system of nonlinear differential equations with piecewise linear characteristic is obtained by considering proper conditions at initial and final point of every linear characteristic and by establishing equations for the period.

In the case of piecewise smooth linear characteristic the effects of jump are taken into account. The case of characteristic consisting of 3 broken lines is discussed in detail, and it is shown that this case can be discussed by transforming the characteristic into $\int$ -shaped one by affine transformation.

The method can be applied to many practical cases if work of calculation can be overcome. M. Kataoka, Japan

2916. Bertram, G., Error estimation for the Ritz-Galerkin method in eigenvalue problems (in German), *ZAMM* **37**, 5/6, 191–201, May/June 1957.

For the ordinary eigenvalue problems of the one-member class, paper gives lower bounds and asymptotic relations. The Ritz-Galerkin method is proved to be convergent.

From author's summary

2917. Greenspan, D., Note on nine-point analogues of Laplace's equation, *J. Franklin Inst.* **264**, 6, 453–455, Nov. 1957.

In a previous note [AMR **10** (1957), Rev. 3160], author proved under certain assumptions that subject analog is "best." He now proves it is essentially unique. Y. L. Luke, USA

2918. Saltzer, C., Discrete potential theory for two-dimensional Laplace and Poisson difference equations, *NACA TN* 4086, 42 pp. + 7 tables + 5 figs., Jan. 1958.

A method is given for solving problems associated with Laplace and Poisson equations which, in general, require considerably fewer equations than the usual methods; it also gives a convergent solution by the method of successive approximations. For infinite regions, by this method, the exact solution for the Dirichlet and Neumann problems can be found by solving a system of equations with as many variables as there are boundary points of the region. In addition, at each stage of the iteration a best possible estimate of the error of the approximate solution with respect to the exact solution of the difference equation for the Dirichlet problem is furnished, and, for the Neumann problem, a bound for the error of the normal difference of the approximate solution is given. From author's summary by E. Volterra, USA

2919. Klioth-Daszynoki, M. I., One method of solving the two-dimensional problem in potential theory (in Russian), *Nauch. tr.*

Leningr. inzh.-stroit. in-ta no. 17, 11–27, 1954; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6828.

The integration of a Poisson equation with a boundary condition $U = U_0$ is analyzed. Representing it in the force $LL^*U(x,y) = f(x,y)$, where $L = (\partial/\partial x) + [i(\partial/\partial y)]$, $L^* = (\partial/\partial x) - [i(\partial/\partial y)]$, the solution is reduced to two equations

$$Lg(x,y) = f(x,y), \qquad L[L^*U(x,y) - g(x,y)] = 0.$$

Solution of the last-named equation with fulfillment of the boundary condition is performed by means of a series according to known polynomials. As an example, the case is examined of a square plate with a uniformly distributed load.

V. V. Krylov
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2920. Alexandrov, A. Ya., Stresses and displacements in an elastic space and a semi-space under the action of a load evenly distributed along an annulus (in Russian), *Trudï Novosibir. in-ta inzh. zh.-d. transp.* no. 11, 62–88, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7666.

Formulas are derived representing, in elliptical integrals of the first, second and third kinds, the stresses and displacements in the cases indicated by the title.

N. A. Rostovtsev
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

2921. Christensen, B., Discussion and solution of the cubic equation, *Acta Polyt.* no. 238, 19 pp., 1957.

A new method suggested by Prof. A. E. Bretting for solution of the ordinary cubic equation through solution of a reduced equation containing only one parameter which indicates the nature of the roots.

The reduced equation is solved directly by means of a slide rule or by simple explicit approximation formulas. Further, an iteration formula is given so that the roots may be calculated with as great accuracy as desirable.

For use in estimates, a diagram is given from which the real roots of the reduced equation may be read directly.

From author's summary

2922. Morris, J., and Head, J. W., A note on the escalator process. *Aircr. Engng.* **26**, 309, 388–389, Nov. 1954.

If an algebraic polynomial equation has roots which are negative if real and has negative real parts if complex, the coefficients must satisfy certain fundamental conditions originally formulated by Routh. These conditions are here derived by comparatively simple algebra for the sextic equation by a method which can be generalized; its extension of the eighth and tenth degree is indicated.

The case of damped Lagrangian frequency equations is considered as an appropriate epilogue.

From authors' summary

Book—2923. Modern computing methods, London, Her Majesty's Stationery Office (NPL Mathematical Tables Series no. 16), 1957, vi + 129 pp. 10s. 6d. (Paperbound).

Booklet contains a series of notes on computations based on lectures by the staff of the Mathematics Division of the National Physical Laboratory. Emphasis has been placed on rendering mathematical problems in such a form that they may be solved conveniently by high-speed digital computers.

The first four chapters cover algebraic equations. Chapters 1, 2, and 4 are concerned with the basic problems, the solution of simultaneous linear algebraic equations, the inversion of matrices, and the determination of their eigenvalues and eigenvectors. Chapter 3 considers the determination of the real and complex roots of a polynomial.

A brief summary of the theory of finite differences is given in chapter 5 and used in chapters 6 and 7 to solve ordinary differential equations, respectively, of boundary-value and initial-value types.

Chapter 8 considers the solution of hyperbolic partial differential equations by the method of characteristics. Chapter 9 discusses various methods of solving parabolic and elliptic partial differential equations.

Chapter 10 describes the use of relaxation methods for successive approximation. Chapters 11 and 12 present the problems and techniques in constructing mathematical tables. A bibliography of books and papers on various topics of numerical analysis is included in the appendix.

The booklet is not intended as a textbook for students, as background materials have been omitted by necessity of the size of the volume. For practicing engineers with sufficient mathematics training, reviewer believes that the booklet presents a good general summary and serves this purpose very well.

H. Lin, USA

Book—2924. Korn, G. A., and Korn, Theresa M., Electronic analog computers (d-c analog computers), 2nd ed., New York, McGraw-Hill Book Co., Inc., 1956, vii + 452 pp. $7.50.

The general arrangement is the same as that of the first edition [AMR **6** (1953), Rev. 330] but most of the book has been entirely rewritten. The chapter titles are essentially the same as in the first edition, viz: (1) Introduction to d-c analog computers, (2) Practical setup procedure, (3) The application of d-c analog computers to representative practical problems, (4) Theory and design of linear computing elements. Coefficient-setting potentiometers and operational amplifiers, (5) D-c amplifiers for computer applications, (6) Multipliers and function generators, (7) Auxiliary circuits and computer operation, (8) The design of complete d-c analog-computer installations.

A considerable amount of material has been added, the principal items being: various methods for handling scale factors; simulation of dynamical systems, including constraints and limit stops; simulation of nonlinearities, statistical design criteria; applications to automobile suspension systems, industrial process control, linear programming, and partial differential equations; direct-analog operational amplifiers; error analysis of linear differential equation solvers; commutator stabilization and photoelectric choppers, transistor d-c amplifiers (very brief); recent techniques in analog multiplication and generation of functions (also functions of several variables); modern automatic control techniques, the current philosophy of computer design, descriptions of modern computer installations, tables of "trick" computer setups, bibliography enlarged and brought up to date.

The book furnishes a comprehensive source of design information on d-c computer components and systems. As such it will be useful to those engaged in the development of instruments and industrial control devices. It should also serve to acquaint those in other fields of research with the possibilities and limitations of analog computers. A knowledge of elementary electronics and elementary differential equations is adequate background for reading the book, but the heavy emphasis on design and operational techniques leads the reviewer to doubt its suitability as a textbook.

A minor suggestion: Since all cross references are by section numbers it would be helpful if, in later editions, these were printed at the top of each page.

H. D. Block, USA

2925. Lawler, E. A., and Druml, F. V., Hydraulic problem solution on electronic computers, *Proc. Amer. Soc. civ. Engrs.* **84**, WW I (*J. Wwys. and Harbors Div.*), Pap. 1515, 39 pp., Jan. 1958.

2926. Greenspan, D., Ulrick, B., and Matsuno, S., On an analog solution of two-point boundary-value problems, *Rev. sci. Instrum.* **28**, 12, 1040–1042, Dec. 1957.

The two-point boundary-value problem of ordinary differential equations is reduced to two initial-value problems, each of which can be easily solved by analog equipment. The computer can judiciously combine these results to yield a solution of the boundary-value problem. The methods involved are described analytically and an example solved on the REAC is provided. A complete diagram of the electronic mechanization is provided.

From authors' summary

2927. Robinson, H. G. R., An analogue computer for convective heating problems, *Aero. Res. Counc. Lond. curr. Pap.* 374, 15 pp. + 10 figs., 1957.

R-C network to compute temperature distribution in multilayer wall is described. Radiative and convective boundary conductance, the former represented by biased diode circuit imposing a voltage/current curve at terminal. Curve to be adjusted in iterative procedure.

V. Paschkis, USA

Book—2928. Canning, R. G., Installing electronic data processing systems, New York, John Wiley & Sons, Inc., 1957, xiii + 193 pp. $6.00

A wealth of information is available from manufacturers and others on application of large-scale, general purpose, electronic digital computers to business data processing. Very little has been written to alert management to need for careful organizational preparation, staffing and selection of personnel prior to installation.

Mr. Canning fills this void by presenting case study of typical installation, based on experience of composite group of pioneer EDP users. Responsibility of top management for installation program is clearly defined and there is excellent treatment of complexity and cost of machine programming. Book has many charts showing typical information flow planning and gives realistic time scales for EDP implementation. These are areas too often neglected in enthusiastic fervor to participate in the wonderful new world of electronics.

This is a well-written practical book recommended to any management contemplating installation of EDP equipment. Author has confined subject matter to large-scale, centrally located installations. Recent developments involve use of communications channels to distant offices and multiplicity of input-output devices as part of integrated installation. In many such applications, "on-line," as well as "off-line," functions are processed by either special or general purpose equipment, or both. The potential user of such EDP systems will find book helpful, but not complete in coverage of installation problems.

E. L. Schmidt, USA

2929. Ware, D. H., Martiny, W. J., and Maginniss, F. J., Electronic data processing machines, *Mech. Engng., N.Y.* **79**, 7, 632–633, July 1957.

2930. Computing Mechanisms—I; Computing Mechanisms—II, *Prod. Engng.* (Design Digest Issue) **28**, 15, F2–F6, Oct. 1957.

2931. Sexton, C. R., Mathematical tables, *Prod. Engng.* **28**, 7, 183–194, July 1957.

Book—2932. Federer, W. T., Experimental design: theory and application, New York, The Macmillan Co., 1955, xix + 544 pp. + 47 pp. prob. $11.00.

Value to the engineer of methods of designing experiments having statistical basis has been discussed previously [AMR **8** (1955), 405–409]. The question is whether this book meets the need of the engineer. Note the author's correct thesis that it is useless to design experiments if simple principles (chapter 1) are not observed; many of these are nonstatistical.

Sixteen chapters cover principles of scientific experimentation, statistical tools and concepts, randomized designs, latin squares, factorial experiments, confounding, split plots, incomplete block and balanced designs, covariance analysis. Author's presentation is as simple as the subject allows and coverage is good. Problems on each chapter enable the reader to test his grasp of contents. Engineers are advised to adopt one book on this subject and progressively to learn how to use it. This comprehensive book is suitable.

R. L. Brown, England

2933. Longuet-Higgins, M. S., Statistical properties of an isotropic random surface, *Phil. Trans. roy. Soc. Lond. (A)* **250**, 975, 157–174, Oct. 1957.

A number of statistical properties of a random moving surface are obtained in the special case when the surface is Gaussian and isotropic. The results may be stated with special simplicity for a 'ring' spectrum when the energy in the spectrum is confined to one particular wave length $\overline{\lambda}$. In particular, the average density of maxima per unit area equals $\pi/[2(3)^{1/2}\,\overline{\lambda}^2]$, and the average length, per unit area, of the contour drawn at the mean level equals $\pi/[(2)^{1/2}\,\overline{\lambda}]$.

From author's summary

2934. Gayen, A. K., and Jogdeo, S. S., On the sampling distribution of mean square successive difference, Proceedings of the First Congress on Theoretical and Applied Mechanics, Nov. 1–2, 1955, 253–260. Kharagpur, Indian Inst. of Technology.

A sample sequence $x_i (i = 1,2,\ldots,n)$ is taken in temporal order from a population with a drifting mean and a constant variance σ^2. In this case the quantity $s^2 = \Sigma (x_i - \overline{x})^2/(n-1)$ does not provide an adequate measure of dispersion. Due to J. v. Neumann, R. H. Kent and others, the mean square successive difference $\delta^2 = \Sigma (x_i - x_{i+1})^2/(n-1)$ is used instead of s^2. The authors derive the frequency function of δ^2 for large samples and present a table showing the moments and cumulants of $x = (n-1)\,\delta^2/2\sigma^2$ and $y = (n-1)\,s^2/\sigma^2$.

H. F. Buckner, USA

2935. Richardson, W. J., Work sampling applied to material handling, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-96, 5 pp.

2936. Head, J. W., and Oulton, G. M., Fitting curves to experimental data by least squares, *Aircr. Engng.* **24**, 343, 268–270, Sept. 1957.

Suppose there are a number n of experimentally derived pairs of corresponding values of an independent variable (x) and a dependent variable (y). It is assumed that a known function Y of x and y is a polynomial in some other known function X of x and y. For a polynomial of given degree n, the least-squares technique for determining the coefficients is well known; here authors show geometrically how the goodness of fit is affected when n is raised from 1 to 2, the number n of given pairs of corresponding points being 5. The results suggest that the five points are not usually placed so that the fit is appreciably better for $n = 2$ than for $n = 1$, and that it is seldom useful to attempt to fit any nonlinear curve to experimental results.

From authors' summary

Book—2937. Luzadder, W. J., Graphics for engineers, New York, Prentice-Hall, Inc., 1957, x + 597 pp. $8.65.

Book is practical in nature and the discussion of theoretical matters is intentionally brief. It deals mainly with mechanical drawing. The book is intended primarily for mechanical and electrical engineering students, but is equally usable by the engineer in practice. It contains good information also for European engineers using a different system of mechanical drawing.

The main chapters following the treatment of elements cover the multiview representation, sectional views, free-hand drafting, pictorial sketching and drawing, basic descriptive geometry, developments and intersections, vector geometry, representation and specification of different machine element types, size description, design and communication drawings, engineering graphs, charts and alignment charts, graphical calculus and the geometry of gears and cams. Graphical symbols, tables for construction and a list of additional ones are published in a useful appendix. A short glossary of shop terms is attached. (Reviewer believes the definition of weld is too peculiar.) It is followed by a well-chosen and organized bibliography of treated and allied matters, and an index.

Discussion of the subject is clear-cut and well arranged. Reviewer should emphasize that the book is outstandingly apt to develop the power of visualization. It considers the recent advancement of mechanical drawing and the development of standards. The selection of the large number of figures is excellent, and presents the author as a man of great experience.

The plentiful and varied problems embrace not only theoretical ones but mostly those which arise in engineering practice, with special reference to the progression of designing.

T. Gerey, Hungary

Book—2938. Polanyi, M., compiled by, Dictionary of textile terms [Textil Fachworterbuch], New York, Pergamon Press, 1956, xi + 328 pp. $10.00.

This English-German and German-English dictionary has 18,000 entries in each section. The editors

2939. Grigorayan, A. T., The history of the principle of integral variations in mechanical science (in Russian), Problems of the history of natural science and technology, Pt. I, Moscow, Akad. Nauk, SSSR, 1956, 24–33; *Ref. Zh. Mekh.* no. 12, 1956, Rev. 7999.

It is particularly pointed out that the development of the principles of variational analysis is due to the work of such leading scientists as Euler, D'Alembert, Lagrange, Hamilton, Ostrogradsky, Gauss, Jacobi, N. E. Joukowsky, and S. A. Chaplygin.

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

Book—2940. Jeffreys, H., Scientific inference, 2nd ed., New York, Cambridge University Press, 1957, viii + 236 pp. $4.75.

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 2978, 3275, 3375, 3383)

Book—2941. Stephens, R. C., and Ward, J. J., Applied mechanics, London, Cleaver-Hume Press Ltd., 1957, xi + 244 pp. 12s. 6d.

Book is a brief summary of the basic principles of mechanics of motion of particles, rigid bodies, and deformable media. Both statics and dynamics are included. Many examples are presented in which the basic principles are applied to practical problems involving moving vehicles, machine parts, vibrating systems, statics of simple structures, simple stress analysis, beam and torsion theory, fluid statics and fluid flow.

Book is not suitable for beginning student, as the discussion articles preceding the examples do not include enough detail for a clear understanding of the examples. It would be a good review source for a student who has already studied statics, dynamics, strength of materials, and fluid mechanics. The problems to be worked by the students are of various types, some require descriptive answers, others require considerable calculation.

H. J. Plass, Jr., USA

2942. Barnes, G., Study of collisions. I. A survey of the periodical literature, *Amer. J. Phys.* **26**, 1, 5–8, Jan. 1958.

A review of the periodical literature on the subject of impact and the coefficient of restitution ϵ shows that the problem depends not only on the materials (elastic moduli) of the colliding objects, but also on (1) their relative normal velocity at the instant of impact, (2) their shapes and sizes, (3) their masses, and (4) the medium in which the impact occurs.

From author's summary

2943. Barnes, G., Study of collisions. II. Survey of the textbooks, *Amer. J. Phys.* **26**, 1, 9–12, Jan. 1958.

A survey of physics and engineering textbooks indicates that there is lack of agreement among the authors on the subject of impact and the coefficient of restitution as well as disagreement between the textbook authors and the writers of the articles in the periodicals. The confusion arises primarily because of (1) the way in which the coefficient of restitution ϵ is so often defined, (2) the nature of the usual discussions of it, and (3) the reason given for ϵ being less than unity for most collisions between objects of ordinary size. Ways of eliminating the difficulty are discussed.

From author's summary

2944. Rosenberg, R. M., On the dynamical behavior of rotating shafts driven by universal (Hooke) couplings, *J. appl. Mech.* **25**, 1, 47–51, Mar. 1958.

Author investigates the influence of Hooke-joint angularity on the critical speed of a shaft supported by two such joints at the end. When angular velocity and torque are constant in the driving shaft then they are functions of time and angularity in the driven shaft. A mathematical analysis of the motion is given which leads to Mathieu's equation. When no torque is transmitted there is instability whenever the driving speed is an odd-integer submultiple of the familiar critical speed; at these instabilities the rate of amplitude increase is small in comparison to that at the critical speed. When a torque is transmitted the shaft appears to be stable when this torque exceeds a certain critical torque; otherwise there are instabilities at speeds near to 1/2, 1/3 . . . times the critical speed. O. Bottema, Holland

2945. Young, L. H., Putting a satellite into outer space, *Control Engng.* **5**, 1, 99–102, Jan. 1958.

Complete control of space vehicles is still an unsolved problem. Launching a satellite takes a combination of on-board control instrumentation and command signals from the ground. Author looks at satellite control problems for the present and the future.

From author's summary

2946. Mangeron, D. I., On the reduced accelerations of any order and on some of their extremal properties *(in Russian), Proc. Acad. Sci. USSR, Appl. Phys. Section* **112**, 1–6, 57–58, Jan.–Feb. 1957. (Translation *Doklady Akad. Nauk SSSR* **112**, 1–6, 27–28. Translated copies obtainable from Consultants' Bureau, New York City.)

Five theorems are stated without proof concerning geometrical properties of the n-th derivative of the acceleration vector of one given point of a rigid body in planar motion relative to another. The last theorem states that the collection of such n-th order vectors for all points of the body relative to a single point form a figure similar in shape to the original body. Further, the figure makes an angle with the body, for which the formula is given.

C. M. Ablow, USA

2947. Cross, C. A., An analogue computer for the vertical rocket landing and take off problems, *J. Brit. interplanetary Soc.* **68**, 1, 7–17, Jan./Feb. 1956.

2947A. Symposium on high speed experimental tracks, *Jet Propulsion* **27**, 9, Sept. 1957.

2948. Egbert, B. R., and Ankeney, D. P., Supersonic track facilities at the Naval Ordnance Test Station, 985–991.

2949. Bonnett, M. E., Aberdeen Proving Ground ballistic track, 992–995.

2950. Seger, R. R., Tract testing at the Air Force Flight Test Center, 995–997.

2951. Hendricks, R. K., Tract testing at the Air Force Armament Center, 997–998.

2952. Davies, H., and Smith, D. S., Design considerations of two large liquid rocket sled pusher vehicles, 999–1006.

2953. Roth, C. E., Jr., and Poland, H. M., Liquid rockets for supersonic sleds, 1006–1011.

2954. Carroll, K. L., and Northrop, C. L., Redstone Arsenal ballistic ramp, 1011–1013.

2955. Eber, G. R., The capabilities of the Holloman track, 1013–1017.

2956. Barr, G. M., and Morrison, S. C., Measurements of vibration environment in a supersonic liquid propellant rocket sled, 1017–1021.

2957. Beutler, F. J., and Rauch, L. L., Precision measurement of supersonic rocket sled velocity (Part I), 1021–1024.

2958. Hegenwald, J. F., Jr., and Murphy, E. A., Jr., Sled testing the emergency escape system: the human factor, 1025–1028.

2959. Mohrlock, H. F., Jr., The development of RESCU Mark I, 1028–1033.

2960. Barr, K., and Steeger, E. J., Supersonic rain erosion testing of missile radomes, 1034–1037.

Servomechanisms, Governors, Gyroscopics

(See also Revs. 2996, 3142, 3198)

Book—2961. Shannon, C. E., and McCarthy, J., edited by, Automata studies, Princeton, N. J., Princeton University Press (Annals of Mathematics Study 34), ix + 286 pp. $4. (Paperbound)

This book is a collection of papers which deal with various aspects of automata theory. This theory is of interest to scientists in many different fields and, correspondingly, among the authors are workers who are primarily logicians, mathematicians, physicists, engineers, neurologists and psychologists. The papers include some which are close to pure mathematics; others are essentially directed to the synthesis problem, and some relate largely to philosophic questions. There is also a certain amount of overlap, the same problem being handled from somewhat different points of view by different authors.

The papers have been divided into three groups. The first group consists of papers dealing with automata having a finite number of possible internal states. In the usual quantized model of this type, the automaton has a finite number of inputs and outputs and operates in a quantized time scale. Thus such a device is characterized by two functions of the current state and input, one function giving the next state and the other the next output. Although seemingly trivial at this level of description, many interesting problems arise in the detailed analysis of such machines. Indeed, it should be remembered that essentially all actual physical machines, and even the brain itself, are, or can be reasonably idealized to be, of this form.

The second group of papers deals with the theory of Turing machines and related questions, that is to say, with automata having an unlimited number of possible states. The original Turing machine (since then recast in many different forms) may be described as follows. Let there be given a tape of infinite length which is divided into squares and a finite list of symbols which may be written on these squares. There is an additional mechanism, the head, which may read the symbol on a square, replace it by another or the same symbol and move to the adjoining square to the left or right. This is accomplished as follows: At any given time the head is in one of a finite number of internal states. When it reads a square it prints a new symbol, goes into a new internal state and moves to the right or left depending on the original internal state and the symbol read. Thus a Turing machine is described by a finite list of quintuplets such as 3, 4, 3, 6, R which means: If the machine is in the third internal state and reads the fourth symbol it prints the third symbol, goes into the sixth internal state and moves to the right on the tape. There is a fixed initial internal state and the machine is supposed to start on a blank tape. One of the symbols represents a blank square and there may be given a state in which the machine stops.

The third section of the book contains papers relating more directly to the synthesis of automata which will simulate in some sense the operation of a living organism. Ashby discusses the problem of designing an intelligence amplifier, a device which can solve problems beyond the capacities of its designer. MacKay, dealing with the same general problem, suggests means for an automaton to symbolize new concepts and generate new hypotheses. Uttley studies from a still different point of view the problem of the abstraction of temporal and spatial patterns by a machine, that is, the general problem of concept formation.

From book preface by Y. S. Touloukian, USA

Book—2962. Hengstenberg, J., Sturm, B., and Winkler, O., Measurement and regulation in the chemical industry [Messen und Regeln in der chemischen Technik], Berlin, Springer-Verlag, 1957, xix + 1261 pp. 146 DM.

Editors have the cooperation of 31 experts from German industry to prepare the nine chapters: (1) Temperature measurement, (2) Amount, flow, and content measurement, (3) Pressure difference measurement, (4) Physical analysis methods, (5) Electrochemical measuring methods, (6) Special industrial methods, (7) Regulation methods, (8) Specifications and aids for planning and management of measuring and regulating installations, (9) Organization for industrial control.

Most chapters are organized into a number of sections based on the type of equipment or the physical property used for the measurement; thus the fourth chapter on physical analysis is divided into 8 sections by different authors: (1) optical methods, (2) gas analysis based on paramagnetism, (3) analysis from density, (4) gas analysis from thermal conductivity, (5) analysis based on thermal changes in a chemical reaction, (6) volumetric methods, (7) electrolytic conductivity, and (8) moisture content.

All chapters are equally thorough in their treatment of the subject. Under regulation methods, a section discusses American and English controllers by company name. Non-German equipment is usually discussed as well as German equipment and methods. There are ample illustrations in all chapters.

This is an encyclopedic work done in the usual thorough German fashion.

K. A. Kobe, USA

2963. Azgapetian, V., System considerations in instrument dynamics, *Aero. Engng. Rev.* **16**, 10, 69–72, Oct. 1957.

2964. Babister, A. W., Determination of the optimum response of linear systems (zero-velocity-error and zero-acceleration-error systems), *Quart. J. Mech. appl. Math.* **11**, 1, 119–128, Feb. 1958.

Extension is made of previously developed method for determination of optimum response of certain linear systems with constant coefficients. Necessity of compromising optimum velocity or ac-

celeration response with displacement error is shown to exist. Paper is difficult to read without referral to previous papers.

L. Becker, USA

2965. Trockii, W. A., On canonical mappings of the equations of the theory of automatic regulation in the case of multiple roots (in Russian), *Prikl. Mat. Mekb.* **21**, 574–577, 1957.

The equation of a very general regulating system may be put in the form

$$\dot{x} = bx + bf(\sigma), \ \sigma = jx \qquad [1]$$

where x is an n-vector, f, σ are m-vectors, and b, b, j constant matrices. Author examines in detail the reduction of [1] to a canonical form when b has multiple characteristic roots. [References: Bromberg, "Stability and self-oscillations of impulsive regulating systems," Oborongiz, 1953; Troickii, *Prikl. Mat. Mekb.* **17**, 1953; Lur'ie, ibid, **12**, no. 5, 1948; also, "Some nonlinear problems of the theory of automatic regulation," Gostekhizdat, 1951.]

S. Lefschetz, Mexico

2966. Fedorov, S. M., The synthesis of parallel corrective networks for servo systems by means of the logarithmic frequency response method, *Automation and remote control, USSR* **17**, 9, 937–946, Sept. 1956 (Consultants' Bureau Translation *Avtomatika i Telemekhanika* **17**, 9, 846–852).

Paper presents a method for effecting the transition from logarithmic amplitude characteristics of the type 20 log $| 1 + K_{fb} \cdot (jw) |$ to logarithmic amplitude characteristics of the type 20 log $| K_{fb} (jw) |$; this process considerably simplifies the synthesis of parallel corrective networks.

From author's summary

2967. Hillsley, R. H., Analyzing control systems graphically, *Control Engng.* **3**, 154–161, Sept. 1956.

Article presents an application, by way of instructional example, of slope-line integration method developed by Paynter [title source, Feb.-Mar. 1955]. Various kinds of nonlinearity, such as square roots, saturation, thresholds, on-off control, sampling control, are introduced and dealt with. Reviewer has no doubt about the potential usefulness of the basic technique as a powerful and convenient form of numerical analysis. In this article, however, the explanations of the steps involved are, in reviewer's opinion, scrappy to the point of unintelligibility. Errors appear to have crept into Fig. 3, where initial values are added before (instead of after) integration.

R. Hadekel, England

2968. Meerov, M. V., Estimating the performance of control systems according to their stability margin with respect to modulus, phase and the quantity M (in Russian), *Automation and remote Control (USSR)* **17**, 10, 963–970, Oct. 1956. (Translation *Avtomatika i Telemekhanika* **17**, 10, 865–870. Translated copies obtainable from Consultants' Bureau, New York City.)

This paper discusses plots on the complex plane of transfer functions from which the cut-off frequency, phase margin, and the magnitude ratio of the peak on the amplitude-frequency response curve can be readily determined for a closed-loop control system. Author gives examples of higher-order systems where small phase margins yield better response than larger ones.

R. Oldenburger, USA

2969. Khokhlov, V. A., The computation and analysis of the dynamics of restrictor hydraulic amplifiers (in Russian), *Automation and remote Control (USSR)* **17**, 10, 971–980, Oct. 1956. (Consultants Bureau Translation *Avtomatika i Telemekhanika* **17**, 10, 871–879. Translated copies obtainable from Consultants' Bureau, New York City.

Mathematical theory for a hydraulic amplifier of the dog-valve type is developed in this paper. Equations derived enable the designer, given certain constants of the amplifier, to determine other constants, such as the time constant of the unit. Assumptions are made so that the hydraulic amplifier can be treated as a first-order lag. The paper includes results of experiments intended to verify the theory.

R. Oldenburger, USA

Translation Courtesy Consultants Bur., Inc.

Translated copies may be purchased from above source.

2970. Matthews, J. T., Jr., Analytical investigation of acceleration restriction in a fighter airplane with an automatic control system, *NACA TN* 4179, 10 pp. + 10 figs., Jan. 1958.

In order to keep aircraft highly maneuverable and yet safely within their structural limitations, it has become necessary to consider methods of automatically restricting acceleration. The problem is essentially one of limiting the output of a dynamic system by operating on the input in a way which will not unduly restrict the dynamic response of the system to pilot input.

The method of this paper was to assume an automatic power control system consisting of a servo loop with normal acceleration feedback. With large feedback gains, and with inner loops of pitching rate and acceleration added to further speed up and damp the response, it was hypothesized that acceleration limiting would be satisfactorily accomplished by simply limiting the command to the control system.

The results are in the form of analog computer solutions of the time history of normal acceleration following a rapid ramp input for several aircraft speeds and center of gravity positions. The aircraft was high subsonic in performance. It was concluded that the best results were obtained with pitching rate and acceleration feedback added in the sense to resist changes in pitch angle.

Reviewer believes that the method of this paper can be essentially summarized by saying that it is an attempt to improve the aircraft dynamic response to the point where a simple limit on the input would suffice as an output limiter. This improvement is provided by standard artificial stability techniques. The approach then seems to bypass the real problem which is to provide limiting of an aircraft which has poor dynamic behavior with or without artificial stability.

P. A. Reynolds, USA

2971. Kirsch, D. B., Wenzel, L. M., and Hart, C. E., Experimental investigation of turbojet-engine multiple-loop controls for nonafterburning and afterburning modes of engine operation, *NACA TN* 4159, 61 pp., Jan. 1958.

Multiple-loop controls optimized rotor speed and turbine-discharge temperature transients during thrust increase and afterburner ignition by manipulation of engine fuel flow and exhaust-nozzle area. Good engine transient performance characteristics were obtained with a control system in which engine speed was controlled by manipulation of exhaust-nozzle area and turbine-discharge temperature by engine fuel flow. Acceptable, although more oscillatory, transient responses were obtained with a control system in which speed was controlled by manipulation of engine fuel flow; turbine-discharge temperature was controlled by manipulation of exhaust-nozzle area; and a noninteraction gain term was incorporated from the speed- to the temperature-control loops.

From authors' summary

2972. Bernet, E., Control valves. I. Operating characteristics (in German), *Regelungstech.* **4**, 5, 108–112, 1956.

2973. Bernet, E., Control valves. II. How to select them in practice (in German), *Regelungstech.* **4**, 6, 132–138, 1956.

2974. Peinke, W., Pneumatic controls testing methods and testing results (in German), *Regelungstech.* **5**, 7, 231–238, 1957.

It is the object of this treatise to examine pneumatic controllers where they fall short of the ideal behavior and to determine the true single causes of the imperfections. First, the working method

of such controllers is explained with the aid of block diagrams. Next, numerous static measuring methods for gaging individual functions are stated and the results of these checks are discussed. A number of additional testing methods applicable to ratio-controllers are stated. Of the dynamic testing methods only such measuring of transfer functions as are simple to apply are dealt with, together with their evaluations. Finally, a suggestion is offered for the standardization of procedure in the measuring methods here described. From author's summary

2975. Coulshed, W. F., and Moore, D. S., A versatile control equipment for fatigue testing, *Aircr. Engng.* **24,** 341, 219–221, July 1957.

2976. Medvedev, S. S., Concerning certain laws governing the functioning of a human operator (in Russian) *Automation and remote Control (USSR)* **17,** 11, 985–999, Nov. 1956. (Translation *Avtomatika i Telekbanika* **17,** 11, 1103–1120. Translated copies obtainable from Consultants' Bureau, New York City.)

Experiments are described in which human operator follows moving index. Response to uniform velocity, uniform acceleration, harmonic oscillation, etc., is measured. Analysis of data provides equation defining average responses of operator.

R. N. Arnold, Scotland

2977. Ward, J. R., A note on the intermittency of a human operator in a control system, Aero. Res. Consult. Comm. aero. Res. Lab. Melbourne, Austral., H. E. no. 2, 12 pp., June 1957.

Vibrations, Balancing

(See also Revs. 3190, 3370, 3387)

2978. Lee, E. W., Non-linear forced vibration of a stretched string, *Brit. J. appl. Phys.* **8,** 10, 411–413, Oct. 1957.

The equation of motion for forced vibrations of a stretched string, clamped at both ends and driven at center, has been set up. The solution was obtained by considering only the fundamental mode and the displacement of a fixed point on the string. Tests were made and the results compare favorably with theory.

A. Yu, USA

2979. Simanov, S. N., Oscillation of quasilinear systems with a nonanalytic characteristic of nonlinearity (in Russian), *Prikl. Mat. Mekh.* **21,** 244–252, 1957.

Consider a system

$$\dot{x} = Ax + \mu F(t,x,\mu) \qquad [1]$$

where x, F are n-vectors, A a constant matrix, μ a small parameter and F is continuous, with period 2π in t and satisfies the Cauchy-Lipschitz conditions as to x. The problem discussed by the author is the existence of periodic solutions in the *resonance* case, i.e., where the associated homogeneous system (with $F = 0$) has solutions of period 2π. The treatment is of the same nature as in chap. 2 of Malkin's book (which appeared after the present paper): "Some problems of the theory of nonlinear oscillations." Malkin, however, follows the Poincaré method based on a general solution of [1], while the present author uses a different process based on successive approximations. [Additional references: Malkin, *Prikl. Mat. Mekh.* **14,** nos. 1 and 4, 1950; Simanov, ibid., **18,** no. 2, 1954; Coddington and Levinson, *Ann. Math. Statistics* **29,** 19–36, 1952].

S. Lefschetz, Mexico

2980. Kannewurf, C. R., and Jensen, H. C., Coupled oscillations, *Amer. J. Phys.* **25,** 7, 442–445, Oct. 1957.

A method of demonstrating coupled oscillatory motion between physical pendulums using a pair of selsyn motors as the coupling device is described. This type of electrical coupling makes possible the agreement of experimental and calculated values of the normal mode and energy transfer frequencies to better than 1%. Two methods for investigating the coupling as a function of the applied voltage are described and the results presented graphically. From authors' summary

2981. Panovko, Ya., G., Calculation of the external and internal inelastic resisting forces in problems of the applied theory of elastic vibration (in Russian), Problems of dynamics and dynamic strength, no. 1, Riga, Akad. Nauk LatvSSR, 1953, 7–21; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6941.

Paper is a development of an earlier one by the same author [*Ref. Zh. Mekh.* 1954, Rev. 5746] for the case of simultaneous action of external and internal resisting forces. Author adheres to the opinion of N. N. Davidenkov [*Zh. tekhn. Fiz.* **8,** no. 6, 1938] concerning a nonlinear relationship of the internal, nonelastic resisting forces to the amplitude of the deformation; it is shown that the expression for the form of the hysteresis loop is not an essential part of the aforesaid hypothesis. The loop is hence approximated by an ellipse. The external resisting forces are assumed to be viscous. A short survey is included of the different hypotheses on internal inelastic resisting forces. The constrained vibrations of a system with a single degree of freedom are examined. Expressions are given for the resonance amplitudes.

N. I. Bezukhov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

2982. DiPrima, R. C., Coupled torsional and longitudinal vibrations of a thin prismatic bar, Rensselaer Polytech. Inst., AFOSR TN-57-773, Math. Rep. 12, 9 pp. + 2 figs., Feb. 1958.

Although the coupling between torsion and longitudinal fiber normal stress of a straight bar is usually negligible, this coupling may produce a first-order effect if the bar is pretwisted. Paper analyzes theoretically the effect of linear pretwisting (constant $d\tau/dx$) on coupled torsional and longitudinal vibrations of a bar of constant cross section. Assuming small torsional and longitudinal vibrational displacements, governing differential equations are linear and with constant coefficients. Free-free and cantilever beams are considered. Results indicate that in any principal mode, if the beam is thin, one of the natural frequencies will be predominantly torsional and the other predominantly longitudinal. The "torsional" natural frequency will be increased by the pretwisting, especially if the beam is very thin.

M. Morduchow, USA

2983. Burgreen, D., Byrnes, J. J., and Benforado, D. M., Vibration of rods induced by water in parallel flow, ASME Ann. Meet., New York, N. Y., Dec. 1957, Pap. 57-A-97, 11 pp.

An experimental determination was made of the type and magnitude of vibration in the simulated fuel rods of a heterogeneous nuclear reactor with water flowing parallel to the rod axes. Triangular lattices with equivalent hydraulic diameters of 0.0708, 0.198, and 0.470 ft were studied at a single rod length. The test rods employed had a range of natural frequencies of vibration in water of 5 to 25 cps. This range was obtained by using $\frac{1}{2}$ and $\frac{3}{4}$-in.-diam rods made of brass or aluminum, by making some rods hollow and others solid, and by using fixed and pin-ended support conditions. The water velocity was varied from 6 to 21 fps, at room temperature. It was found that the vibration can be significant for reactor conditions. The rod vibration was observed to be self-excited, resulting in the rods vibrating at their natural frequencies independent of the water velocity. A theoretical study of the forces acting on the rods was made from which it appears that ten variables (of which six were varied in these tests) influence the amplitude of

vibration of the rod. A correlation was derived and the resulting equations give a good fit with the test data.

From authors' summary

2984. Pisarenko, G. S., Free vibrations of a load on a beam, taking into account hysteresis losses (in Russian), *Izv. Kievsk. politekhn. in-ta* **18**, 3-13, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 992.

An investigation is made of the free, damping vibrations of a concentrated load on the end of an imponderable cantilever beam. The forces of the inelastic resistance are assumed to be independent of the speed of deformation and are recorded as functions proposed by N. N. Davidenkov [*Zh. tekhn. Fiz.* **8**, no. 6, 1938]. Author assumes the absence of those forces influencing the form of deflection of the beam, when subject to vibration; this permits finding an equivalent concentrated force of inelastic resistance, applied to the end of the bracket; the same problem merges with the investigation of the system of vibrations with one degree of freedom. The basic equation of dying down vibrations (7) is nonlinear and is solved by the method of Krylov-Bogolyubov [Vvedenie v. nelineinuyu mekhaniku, Kiev, 1937]. The final formula of the bending curve of oscillations (43), accurate up to specification, agrees with the formula obtained by the abstractor [see *Ref. Zh. Mekh.* 1954, Rev. 5746]. Good agreement is established with experiment.

Ya. G. Panovko

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

2985. Pisarenko, G. S., Analysis of the energy dissipation in the vibration of bundles of rods (in Russian), Problems of power metallurgy and strength of materials, Kiev, Akad. Nauk USSR no. 1, 40-47, 1954; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6942.

A special test rig is described which makes it possible to determine the damping decrement in relation to the stress level for single bars rigidly held at one end and for bundles of such bars.

Experimental results obtained with varying methods of constraint are correlated, the factors influencing the magnitude of the damping decrement are analyzed, and the relationships determined between the energy losses by dissipation in the material and in the joints of the bundle, respectively.

Yu. A. Mitropol'skii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

2986. Kabulov, V. K., On closed solutions of some engineering problems (in Russian), *Dokladi Akad. Nauk.* no. *UzSSR* 10, 31-36, 1955; *Ref. Zh. Mekh.* no. 12, 1956, Rev. 8547.

The simplest problems on the longitudinal oscillations of a prismatic elastic bar are set out in terms of the methods of characteristics.

V. V. Bolotin

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

2987. Forshaw, J. R., A survey of the alternating pressures exciting high frequency vibrations in gas turbines, *Aero. Res. Counc Counc. Lond. Rep. Mem.* 2989, 20 pp., 1957.

A survey of the predominant harmonic components of the alternating pressures is made for three centrifugal compressors, three axial-flow compressors and a single-stage turbine to ascertain the forces exciting vibration in a compressor or turbine stage. The predominant harmonic components of the alternating pressures in the casing are the first-order components of the impulse from the rotor blades or impeller vanes. Harmonics up to the seventh of these impulses can be detected in parts of the speed range. The alternating pressures in a compressor annulus have components similar to those observed in the casing for the stage but, in addition, have components of greater magnitude excited by dissimilar flows in individual blade passages. The largest orders are those which excite the fundamental flexural mode of vibration of the blades, and the corresponding blade movements amplify the alternating pressures.

The amplitude of the alternating pressures is dependent on the work done in a blade or impeller vane passage, the incidence at entry to the stage, the exit conditions, and the general flow conditions, and there is usually a relative reduction when operating near the design point.

There is a reduction in the alternating pressures with distance from the source, particularly across a blade row.

There are three other sources of excitation at part load: (*a*) Stalling flutter at high positive incidence can occur in axial-flow compressors for blades of low stiffness over wide ranges of operation provided the incidence and mass flow are greater than the boundary conditions; (*b*) alternating pressures can be excited near the surge by one or more stall cells rotating at some fraction of compressor speed; (*c*) at the stalling incidence of a stage, if a proportion of the stage stalls due to dissimilar geometry or flow and the remainder of the stage and compressor as a whole is operating at relatively high efficiency, large alternating pressures of all forcing orders can be excited. This effect is the more severe the lower the natural frequencies of the blades.

From author's summary

2988. Heller, S. R., Jr., Natural frequencies of shaft struts, *J. Amer. Soc. nav. Engrs.* **70**, 1, 137-143, Feb. 1958.

The natural frequency of a beam, built in at its ends and simply supported at a point within its length, is calculated, and is shown to relate to frequency of outrigger supports of ship's propellor shaft. Method is to equate angles of deflection and bending moments, for the two portions of the beam, at the simple support.

Paper suggests author is not familiar with work which has already been done in this field; see for instance, AMR **10** (1957), Rev. 400.

Title is misleading because members are not struts in accepted engineering sense.

D. C. Johnson, England

2989. Sablin, V. I., The vibrations of ribs in the principal directions (in Russian), *Trudi Novosibir. in-ta inzh. zh. d. transp.* no. 11, 217-232, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 990.

2990. Jain, B. S., and Lal, P., Anharmonic pulsations of two-phase homogeneous model, *Bull. Calcutta math. Soc.* **48**, 4, 197-202, Dec. 1956.

The anharmonic oscillations of a two-phase homogeneous model, consisting of a homogeneous core surrounded by an envelope of uniform density, have been studied. The core radius is taken to be half of the total radius of the model and the core density is taken to be 10 times the envelope density. For this model the period of oscillation for the fundamental mode is about double (in fact 2.18) the period of the first mode. In this case we expect considerable skewness. The problem is solved using numerical method, and, for surface amplitude equal to 0.05, it is found that the skewness in the velocity-time curve is 1.43 and the increase in the period is 1.2% of the period for the fundamental mode for vanishing amplitude.

From authors' summary

2991. Hall, A. H., Tulloch, Helen A., Pinkney, H. F. L., and Sarazin, A. C., Graphical and tabulated data on the frequency and modal characteristics of swept cantilevers, *Nat. aero. Establ. LR* 193, 64 pp. + 16 figs. + appendixes A, B, C, June 1957.

This report relates to the vibration of swept cantilevers with parallelogram planform, and contains comprehensive data on the frequency and modal characteristics which are of use in the application of semirigid analysis to preliminary design studies of missile and aircraft dynamics. It contains charts of frequency coeffi-

cients as a function of angle of sweep, aspect ratio, and rigidity ratio, together with interpolation tables covering the corresponding modes and running amplitude ratios (nodal coordinates). A brief discussion of profile camber is illustrated with experimental data, as are the charts and modal tables.

From authors' summary

2992. Johnson, A. J., and Ayling, P. W., Graphical presentation of hull frequency data and the influence of deck-houses on frequency prediction, *N. E. Cst. Instn. Engrs. Ship. Trans.* **73,** 7, 331-368, May-June 1957.

Paper is concerned with the presentation of ship-vibration data in a form aimed at enabling quick estimates of frequencies to be made at the design stage. The subject matter represents one aspect of a comprehensive program of work on ship vibration being carried out by the British Shipbuilding Research Association.

Previously published methods have been adapted for this purpose but, in the light of further experimental results obtained by the authors, it has been possible to extend these methods and suggest certain modifications intended to improve the accuracy of the estimates.

Detailed consideration is given to the flexural rigidity of ships having deck-houses. On the basis of a recently published method for estimating the distribution of longitudinal stresses in deck-houses, a series of calculations was carried out for a wide range of ships in order to derive graphs from which inertia correction factors can be readily obtained. Examples are given illustrating the derivation and use of these factors.

From authors' summary

2993. Kumai, T., Some measurements of acceleration of hull vibration and human sensitivity to vibration, *Rep. Res. Inst. appl. Mech.* **5,** 17, 21-26, 1957.

Paper is a preliminary progress report on some results of the measurements of the acceleration of the ship vibration by the use of the accelerometer. The acceleration of the ship vibration has been directly observed for the range from the two-node frequency to the blade frequency of the hull vibration on the weather deck, and in the rooms of a cargo ship and of two tankers. The threshold of unpleasantness of the horizontal vibration in the cabin of ship is confirmed to be about 15 gal with a maximum acceleration by the present observations.

The duplication of the resonance of the shaft frequency with the blade frequency of the hull vibrations in two tankers has also bee observed, and the human reaction to the vibration in the state of those double resonance has been measured by the accelerometer more clearly than by the vibrograph.

From author's summary

2994. Jones, R. P. N., The use of normal modes in problems of forced vibration and impact, *J. roy. aero. Soc.* **61,** 560, 552-559, Aug. 1957.

The properties of normal coordinates are discussed and applied to forced vibrations of several illustrative systems.

A. I. Bellin, USA

2995. Lowe, R. T., and Crede, C. E., Recent developments and future trends in vibration isolation, *Noise Control* **3,** 6, 21-28, 70, Nov. 1957.

Vibration and shock isolation have for many years been handled as problems requiring separate solutions, imposing conflicting requirements on shock and vibration isolators. How this problem is currently being handled and what the direction of current engineering thought is in this area is one of the topics discussed by two leading engineers in the field. From authors' summary

2996. Conrad, R. W., and Vigness, I., Response spectra by means of oscillograph galvanometers, *J. acoust. Soc. Amer.* **29,** 10, 1110-1115, Oct. 1957.

A response spectrum (shock spectrum) is the response of a series of single-degree-of-freedom systems of given damping to a shock or vibratory motion, as a function of the frequencies of the simple systems. An oscillographic galvanometer is a single-degree-of-freedom system having a rotational response to an exciting current. If the exciting current is made proportional to the amplitude of the motion, the response of the galvanometer to the current will be proportional to that of a single-degree-of-freedom system to the motion, provided their natural frequencies and damping properties are the same. A commercial galvanometer-type oscillograph has been obtained having twelve undamped galvanometer elements with natural frequencies in the range between 10 and 2500 cps. Damping, by electrical means, has been made adjustable between about 3 and 50% of critical. Associated circuitry has been constructed so that electrical playback of recordings of shock and vibratory motions can be conveniently analyzed. Calibration techniques are described and examples are given for analysis of simple and complex shock motions.

From authors' summary

Wave Motion in Solids, Impact

(See also Revs. 2986, 2994, 2996, 3020, 3021, 3031, 3043)

2997. Savin, G. N., and Georgievskaya, V. V., Dynamic forces in a hoisting cable when the load is taken off from an immovable foundation (in Russian), *Dop. Akad. Nauk, URSR* no. 3, 205-211, 1954; *Ref. Zh. Mekh.* no. 12, 1956, Rev. 8555.

The article turns out to be a continuation of the work of G. N. Savin. In determining the maximum forces, the hoisting cable—not a fully elastic aggregate of the variable length—is replaced by an ideal elastic thread of constant length, the top end of which travels upward with some (constant) increase in speed.

Two stages of the hoisting are examined: the taking off of the load from an immovable base and its movement upwards. In this way the problem merges with the integration of heterogeneous wave equation, with initial and boundary conditions, corresponding to the first and second stages of the hoisting. In the results of the examination of this problem formulas are established for the determination of the maximum force in the cable when the load is removed from an immovable foundation:

$$T_{0,\max}^{(\xi=0)} = \left(1.25\,\frac{P}{Q} + 1.558\right) Q$$

and the hoist of the freely suspended load

$$T_{0,\max}^{(\xi=1)} = \left(1.18\,\frac{P}{Q} + 1.2\right) Q$$

Here P and Q, respectively, are the weight of the working part of the cable and the weight of the end load.

V. N. Shevelo

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

2998. Boley, B. A., and Chao, C.-C., An approximate analysis of Timoshenko beams under dynamic loads, *J. appl. Mech.* **25,** 1, 31-36, Mar. 1958.

Author presents a prescription for solving the so-called Timoshenko beam equation when the loading is of the impact type. The principle of virtual work and variational formulas are used. Several examples of semi-infinite beams with end velocity and end

moment loading are treated. Derivations of some of the fundamental equations are given in an appendix.

W. H. Hoppmann, II, USA

2999. Keller, J. B., On solutions of nonlinear wave equations, *Comm. pure appl. Math.* **10,** 4, 523–530, Nov. 1957.

Solution u of the nonlinear wave equation $u_{tt} - c^2\Delta u = f(u)$ satisfying initial conditions for $u(x,0)$ and $u_t(x, 0)$ is proved to become infinite at a finite value of t for a certain class of functions $f(u)$ provided initial data satisfy appropriate conditions. Number of space dimensions n is restricted to be one, two, or three. Same conclusions are also deduced for solutions of the nonlinear Euler-Poisson-Darboux equation, i.e., an equation that differs from the above by an additional term proportional to u_t/t on the left side, for $n = 2$ and $u(x, 0) = 0$.

F. K. G. Odqvist, Sweden

3000. Hartz, B. J., and Clough, R. W., Inelastic response of columns to dynamic loadings, *Proc. Amer. Soc. civ. Engrs.* **83,** EM 2 (*J. engng. Mech. Div.*), Pap. 1213, 15 pp., Apr. 1957.

An analytical investigation of the response of columns to single compressive loadings of arbitrary time history such that the material of the column is strained into the inelastic range is presented in this paper. The column is assumed to have pinned-ends and to have a slight initial curvature or to have the loading applied slightly eccentric to the axis of the column.

The modal superposition approach is used to obtain the equations for the elastic response, while an idealized, one-degree-of-freedom, rigid-plastic system is used to obtain the equations for the ensuing inelastic response, after the strain at some point in the column exceeds the yield strain for the material. Numerical integration is used to obtain solutions for both the elastic response and the inelastic response. A numerical example is worked out and the results compared to the experimentally determined response of an actual column.

From authors' summary

3001. Gurevich, G. I., The problem of the physical bases for the theory of propagation of elastic waves (in Russian), *Trudl Geofiz. in-ta Akad. Nauk SSSR* no. 30, 314–348, 1955; *Ref. Zh. Mekh.* no. 12, 1956, Rev. 8530.

The question is put regarding the equations of dynamics of the theory of elasticity and whether they reflect accurately the process of damping the waves. Author denotes his disagreement with the calculation of viscosity by means of the equations

$$\rho\frac{\partial^2 u}{\partial t^2} = (\lambda + \mu)\,\mathrm{grad}\,\theta + \mu\nabla^2 + \frac{\partial}{\partial t}[(\lambda' + \mu')\,\mathrm{grad}\,\theta + \mu'\nabla^2 u]$$

and proposes substitution of his own equations

$$\frac{\partial}{\partial t}[(\lambda + \mu)\,\mathrm{grad}\,\theta + \mu\nabla^2 u] = \rho\frac{\partial^3 u}{\partial t^3} + \frac{\rho}{T}\frac{\partial^2 u}{\partial t^2} - \frac{k}{T}\,\mathrm{grad}\,\theta$$

where k is Boltzmann's constant, T the period of relaxation. The deductions of the author are based on Boltzmann's principle, taking into account the previous condition of the elastic body. The insufficiency of B. Deryagin's theory [*Zh. geofiz.* **1,** 1931; **2,** 1932], also based on Boltzmann's principle, is referred to. An examination is made of cases of homogeneous deformation, and a physical analysis is given of the solution obtained.

I. S. Arzhanykh

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3002. Dures, L., A more accurate calculation of vaults for longitudinal seismic forces (in Russian), *Transport. str-vo* no. 10, 19–22, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7906.

Improvements are suggested in the method of calculating vaults to resist longitudinal (axial) seismic forces, developed by V. Zavriev. A table is given, simplifying the calculation of vaults with different force parameters.

A. G. Nazarov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3003. Alekseev, A. S., and Babitch, V. M., An effect of screening elastic waves by a thin layer (in Russian), *Uchen. zap. LGU,* no. 177, *Ser. matem. nauk* no. 28, 180–193, 1954; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6920.

The dynamic problem of the theory of elasticity is examined for a system consisting of two homogeneous and isotropic semi-spaces, divided by a thin layer h with accelerated velocities of wave propagation. It is assumed that up to the time constant $t = 0$ the system is in a condition of rest, while at $t = 0$ in one (the upper) of the semi-spaces a point source of waves becomes active, having axial symmetry. The authors state as their purpose the investigation of the field of the waves refracted into the lower semi-space at angles greater than the limit, i.e., the waves for which, according to the laws of seismic geometry, a thin layer must form a specific screen. The problem thus defined is solved by the method of incomplete resolution of the variables, on the assumption that the elastic semi-spaces are identical. In the lower semi-space it is possible to isolate from the total field a longitudinal wave which does not experience reflection in the thin layer. The displacements corresponding to this wave, represented by Fourier-Bessel integration of the Mellin integral, are analyzed and calculated by the steady phase method. The authors thus obtain expressions for the field intensity in the vicinity of the original and fictitious wave fronts, analysis of which leads to the conclusion that, for small thicknesses of the layer, perturbations exist in the lower semi-space which pass through the thin layer, contrary to the laws of seismic geometry, and are of considerable intensity.

Yu. A. Voronin

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3004. Ginzbarg, A. S., and Strick, E., Stoneley-wave velocities for a solid-solid interface, *Bull. seism. Soc. Amer.* **48,** 1, 51–63, Jan. 1958.

Authors present graphs of the velocities of Stoneley waves for a wide range of elastic parameters and density ratios. Over certain ranges velocity ratios are found to be almost independent of Poisson's ratio.

G. W. Housner, USA

3005. Sharafutfinov, V. I., Calculation of frame structures subject to loading of great intensity and small duration (in Russian), *Dokladl Akad. Nauk UzSSR* no. 12, 25–29, 1955; *Ref. Zh. Mekh.* no. 12, 1956, Rev. 8542.

Calculations are made, following known methods, of a symmetrical channel girder frame subject to an evenly distributed impulse. For a concrete case it is shown that the results differ from results obtained by an approximate method of calculation.

A. K. Malmeister

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3006. Buchmann, E., Response of a simple floating structure to underwater explosion attack, *David W. Taylor Mod. Basin Rep.* 1019, 19 pp., June 1957.

The response of a simple floating target simulating a structure subjected to underbottom explosion attack has been determined and correlated with various phases of the explosion phenomena. The target was a wooden block with a bottom consisting of an airbacked steel plate of varied thickness clamped at the edge. The velocity of the wooden block and the relative velocity of the center of the steel bottom with respect to the wooden block were measured. The motion of the center of gravity was found to be the

same as that of the water displaced by the target calculated as if the target were absent. The bottom and top of the target also vibrated in a manner resembling a system of two spring-connected masses. The amplitudes of vibration could be derived from the motion of the water due to the explosion.

A few tests were made to determine the effect on the motion of installing a sponge rubber bottom on the wooden block. The maximum accelerations of the block were reduced.

From author's summary

Elasticity Theory

(See also Revs. 2941, 3032, 3046, 3056, 3066, 3388)

3007. Rongved, L., and Frasier, J. T., Displacement discontinuity in the elastic half-space, *J. appl. Mech.* **25**, 1, 125–128, Mar. 1958.

Authors obtain the Papkovitch functions for an arbitrary displacement discontinuity over a plane bounded area in a semi-infinite elastic isotropic solid, where the plane of discontinuity has an arbitrary orientation with respect to the free boundary. Solutions for displacement are given in term of integrals over the area of discontinuity. The case of a constant-displacement discontinuity over a rectangular area parallel to the boundary is worked out in closed form. D. N. Mitra, India

3008. Zaustin, M. V., On the necessity of fundamental and widened research in strength of materials, *ASTM Bull.* no. 226, 52–61, Dec. 1957.

Author emphasizes inadequacy of conventional theory of elasticity and strength of materials for modern design with its severe weight and reliability requirements, and calls for a new branch of engineering which, applied to metals, might be called "metal mechanics." This science would seek to bridge the gap existing between strength of material as measured in laboratory and strength of part made from this material, which is affected by influence of particular stress system on material properties. Ductility, for example, is not merely the property of the particular material but depends on ratio of shearing to tensile stress. Character of stresses and mode of application can change properties to greater degree than heat treatment, temperature, and chemical composition. "Tensile" stress is really a complex system of stresses which should be broken down into more fundamental components. Resistance to stresses also has a dual nature; only by taking account of duality of stresses and resistances can proper theory of strength be selected.

Author lists test data (mostly not now available) necessary to build up this new science to level where it can become an effective working tool of the designer. Reviewer recommends paper, which is of nonmathematical nature, as interesting and instructive presentation of modern viewpoint seeking to break new ground in this field. C. W. Smith, USA

3009. Niedenfuhr, F. W., On choosing stress functions in rectangular coordinates *J. aero. Sci.* **24**, 6, 460–461 (Readers' Forum), June 1957.

As an example of plane strain, most books on the theory of elasticity discuss the stresses in rectangular beams with distributed loading. The problem is conveniently handled by means of Airy's stress function. None of the standard books on the subject gives a general method of finding a polynomial stress function to fit a particular problem, however. The purpose of this note is to present a general method which is especially useful when the load distribution is itself a polynomial. From author's summary

3010. Distefano, J. N., One-dimensional elastic state of welded connections (in Spanish), *Cienc. y Tecn.* **124**, 619, 141–155, June 1957.

Theoretical stress analysis is presented of welded connections of plates, strips, or bars in arrangements subject to axial force. Stress distribution in two strips of practically the same width and thickness, due to parallel weld fillets with and without transverse end fillet, is considered. Another case is thoroughly investigated in which one strip is rectangular and the other plate has triangular end. J. J. Polivka, USA

3011. Chattarji, P. P., Stresses in a spherically isotropic truncated cone fitted with two rigid spherical caps due to frictional forces acting on the curved surface, *Indian J. theor. Phys.* **5**, 1, 15–18, Mar. 1957.

Using spherical polar coordinates, the equation of equilibrium expressed as a differential equation for w, the azimuthal component of strain, is solved as the product of a function of r only and a function of θ only. Torsional stresses and displacements are then obtained in the form of infinite series.

D. N. Mitra, India

3012. Dutt, S. B., Stresses in an aerolotropic paraboloid of revolution due to frictional force acting on its surface, *Indian J. theor. Phys.* **5**, 1, 11–14, Mar. 1957.

Curvilinear coordinates are used. Shearing stresses being expressed in terms of w, the azimuthal displacement, and of its derivative, equation of equilibrium leads to a differential equation for w which is solved in an infinite series form in terms of Bessel's functions. D. N. Mitra, India

3013. Verma, G. R., Application of Dirac's delta-function in isolated force problems of the semi-infinite elastic solid of isotropic and nonisotropic materials, *ZAMM* **37**, 1/2, 34–38, Jan.–Feb. 1957.

3014. Basheleyshoili, M. O., A solution of the first fundamental boundary problem of statics for an orthotropically elastic body in the case of multiply-linked regions (in Russian), *Soobshch. Akad. Nauk Gruz. SSR* **16**, 8, 577–582, 1955; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6822.

The two-dimensional problem of the theory of elasticity for the case of an orthotropic body the region of which is multiply-linked, i.e. is bounded by an arbitrary number of closed contours of continuously varying curvature which neither intersect nor are tangent to each other, is examined. It is assumed that the displacement vector is defined for each contour.

Author seeks the solution of the equilibrium equations in the projections of the displacement in the form of a particular integral (potential) containing an unknown vectorial function (density) and obtains for this a Fredholm integral equation. Matrix notation is used, as well as a number of results of a research conducted by the present author together with V. D. Kupradze, in which the two-dimensional problem of an orthotropic body with a singly-linked region was investigated [*Ref. Zh. Mekh.* 1955, Rev. 4448]. Proof is given of the existence of a singular solution for the internal problem of a multiply-linked region, as well as for the corresponding external boundary problem. S. G. Lekhnitskii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3015. Suhara, T., On the stresses in beams with discontinuous cross sections, *Rep. Res. Inst. appl. Mech. Kyushu Univ.* **5**, 19, 115–121, 1957.

So-called "two-beam theory," developed by R. W. Cornell, gives fairly good approximation except at the part of the notch. Author presents calculation in which the stress concentration is con-

sidered by introducing a point load at the root of notch. The magnitude of this load is determined from the principle of the minimum potential energy of the entire beam, in which the energy function near the root of notch is obtained by the two-dimensional elasticity theory. Theoretical calculation complies satisfactorily with the experimental (photoelastic) stress analysis, slight discrepancy being in the neighborhood of the discontinuous point.

J. J. Polivka, USA

3016. Gomza, A., Stress-concentration factors—I, *Prod. Engng.* **28**, 6, pp. 211, 213, 215, 217, 219, June 1957.

3017. Gol'denveizer, A. L., Refinement of the theory of the simple boundary effect (in Russian), *Prikl. Mat. Mekh.* **20**, 3, 335-348, May-June 1956.

Better accuracy is attained for known approximate solutions of boundary effects that occur in neighborhood of a certain contour. This contour nowhere touches asymptotic lines of mid-surface. Approximate theory was originally introduced for axisymmetrical shells of revolution by Shtaerman and Geckeler and later improved by Robotnov and the author to include shells of arbitrary contour. In present study, author employes first approximations and considers possibility of higher order of approximations; previously, in each separate term only one principal part of the sum was retained. Lurie's method, though accurate, applies only to axisymmetrical shells of revolution.

Author further investigates integration of his equation. Two orthogonal parameters refer to curvilinear coordinates defining shell's mid-surface with coefficients in first quadratic form. Complex unknown is function of shell's normal deflection and one of four stress functions. Love's notation is used. Further, coordinates are so selected that line, in the neighborhood of which the boundary effect is localized, is included among the lines of parameter while the other parameter remains constant. Taylor's expansion is used.

Author defines first, second, etc., approximations, depending on the number of retained terms in the characteristic equation. He discusses the errors involved in each order of approximation and states that third approximation is not logically consistent due to some coefficients still being unknown. Author demonstrates his technique on cylindrical shell of arbitrary form and on spherical shell.

V. A. Valey, USA

3018. Kinoshita, N., and Mura, T., On boundary-value problem of elasticity, *Res. Rep. Fac. Engng. Meiji Univ.* **8**, 56-62, Feb. 1956.

Authors state the solution of boundary-value problem of elasticity by using a system of Fredholm's integral equation of the second kind. Consequently, the problem of finding the displacement and the stress in an elastic body, when a motion is given to a rigid body contained in it, can be solved analogously to the Robin's problem in the potential theory of finding an equilibrium potential having a constant value in any domain.

T. C. Lin, China

3019. Zawilski, W. W., Elastic design of prestressed sections in flexure by charts or tables, *J. Amer. Concr. Inst.* **28**, 10, 961-988, Apr. 1957.

3020. Mahlmeister, A. K., The deformation and strength of systems capable of twinning (in Russian), Problems of dynamics and dynamic strength, Pt. II, Riga, Akad. Nauk LatvSSR., 1954, 5-20; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 7093.

Continuing a preceeding paper [*Ref. Zh. Mekh.* 1956, Rev. 2540], a twinning polycrystal is simulated by a system of two parallel springs: one, linearly elastic, representing the deformation under normal stresses; and one, nonlinearly elastic, with discontinuous elastic characteristics, representing deformations under tangential (shearing) stresses.

Twinning of the separate laminar of the crystal is simulated by transposing particular sections of the nonlinearly elastic spring into the second position of equilibrium. Such a system, and consequently its analogous twinning medium, exhibits the characteristics of a rational solid body, possessing elasticity, plasticity with accompanying strain hardening, relaxation, Bauschinger effect, etc., creep and fatigue.

The mechanical resistance of the system is conditioned by the duration of application of the load and the rate of deformation; the latter also influences the type of failure.

V. M. Gol'dfarb

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3021. Goltsev, D. I., Strength conditions under varying load in a condition of compound stress (in Russian), Problems of dynamics and dynamic strength, no. 1, Riga, Akad. Nauk LatvSSR, 1953, 47-88; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6911.

A new strength condition is stated for a compound stress state during a symmetrical loading cycle and cophasal time-variation of the stress.

From information in the literature, author postulates the following:

(1) The area of the hysteresis loop (work of internal forces of nonelastic resistance) does not depend on the rate of deformation and is proportional to the $(n + 1)$ power of the stress.

$$\Delta W = d_2 \sigma_0^{n+1}$$

from which it follows that the internal, nonelastic resisting force is:

$$R = c\sigma_0^n \; (1 \leq n \leq 2)$$

(2) The efficacy of the shearing component of the internal, nonelastic resisting force on the area of the octahedron depends on both the tangential and the normal stresses acting on the same area. The magnitude of the shearing component of the internal, nonelastic resisting forces is assumed to be.

$$T = k_1 (\tau_{oct} + K\sigma_{oct})^n,$$

where τ_{oct} and σ_{oct} are the amplitudes of the octahedral tangent and the normal stresses, and n, k_1 and K are material constants.

(3) At the limiting condition, the unit energy of dissipation, determined by the T forces, does not depend on the type of stress.

The strength conditions are determined by calculating the work of the shearing forces in unit volume of the material (for one cycle) corresponding to the plastic micro-deformation responsible for the formation of fatigue cracks; i.e., it is assumed that a safe level of unit energy of dissipation exists, related to the octahedral stresses.

The limiting condition in question is defined as the condition at the endurance limit for the simple stress state (bending, torsion, tension) which is correlated with the work of the nonelastic forces acting on the octahedral area in the compound stress condition. As a result, a relationship is obtained between the stresses in the compound stress condition and the endurance limit in the simple stress condition. The material constants, n and k, vanish from the equation, while the constant K is determined from the endurance limits in bending and torsion.

From a comparison with experimental data in the literature, author concludes the practical validity of the hypotheses and assumptions made.

B. F. Balashov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3022. Procter, A. N., Elastic materials under axial loading, *J. Franklin Inst.* **265**, 2, 125–143, Feb. 1958.

An interesting analysis of how Newton might have looked at material behavior today. F. J. Mehringer, USA

3023. Dudley, D. W., When splines need stress control, *Prod. Engng.* **28**, 25, 56–61, Dec. 1957.

Correct diagnosis of spline-failure problems is a vital first step toward correct design. This article supplies charts and formulas for computing four important types of stresses that must not be exceeded. From author's summary

3024. Shaffer, B. W., and House, R. N., Jr., Displacements in a wide curved bar subjected to pure elastic-plastic bending, *J. appl. Mech.* **24**, 3, 447–452, Sept. 1957.

Equations have been obtained for the displacements and strains within a wide curved bar made of a perfectly plastic, imcompressible material subjected to a pure bending moment which is sufficiently large to cause elastic-plastic stresses. It is found that, whenever the applied load is within 95% of the fully plastic bending moment, displacements and strains in the elastic-plastic problem are of the order of magnitude of the corresponding elastic case. It is also found that, when the bending moment reaches approximately 65% of the fully plastic bending moment, the change in material thickness reaches a maximum. It decreases to zero when the bar becomes completely plastic.

From authors' summary

3025. Raes, P. E., Superposition of plane-stress tensors and its applications in soil mechanics (in French), *Ann. Trav. publics Belg.* no. 4, 5–12, 1956.

Relationships between Lame's ellipse, Mohr's circle, and Weyrauch's circle are presented, and rules of graphical superposition of two or more plane-stress tensors are derived. Results are applied to problems of stability of foundations on cohesive soils, following previous work by Descans [AMR **10** (1957), Rev. 2340]. O. Hoffman, USA

3026. Pride, R. A., and Hall, J. B., Jr., Transient heating effects on the bending strength of integral aluminum-alloy box beams, *NACA TN* 4205, 22 pp. + 1 table + 13 figs., Mar. 1958.

Twenty-five square-tube beams were tested to failure under combinations of bending load and symmetrical heating. The results of tests for skin buckling and maximum strength are compared with theoretical calculations. Results for local buckling are calculated from theories combining the effects of appropriate material properties and thermal stress in both elastic- and plastic-stress ranges. A marked reduction in buckling strength was observed as a result of thermal stress. At failure, the results of all tests correlated well with those calculated by a compression maximum-strength theory based solely on appropriate material properties; this correlation indicates that thermal-stress effects which influence local buckling appear alleviated at maximum load.

From authors' summary by P. C. Dunne, Brazil

3027. Merckx, K. R., The time and temperature dependence of thermal stresses in cylindrical reactor fuel elements, *Trans. ASME* **80**, 2, 505–509, Feb. 1958.

Method of calculating the thermal stresses in cylindrical uranium fuel elements is developed. In absence of better information the author uses a form of strain, stress, temperature, time dependence suggested by Sherby, Orr & Dorn [AMR **7** (1954), Rev. 2154]. The problem is important because of the necessity to insure mechanical integrity of fuel elements in atomic piles.

Temperature ranges of 100 to 350C and 350 to 600C during a 25-minute period of increasing power generation followed by 700 minutes of steady-state operation are considered. It is shown that the stresses calculated by the elastic theory are several times too large even during the heat-up period. In the lower temperature range, plastic deformation theory alone suffices to calculate the initial thermal stresses; in the higher temperature range, creep must also be considered. For both cases creep causes a relaxation of stress during the steady-state conditions. Automatic computing methods were necessary for the practical calculations.

Paper should be of interest also to aeronautical engineers.

P. C. Dunne, Brazil

3028. Thompson, A. C., Thermal stresses around a heated hole in a large glass plate, *J. Amer. ceram. Soc.* **40**, 7, 244–245, July 1957.

The problem of sealing a hole in a cool glass plate under conditions at or above annealing temperatures is examined. By use of the well-known equations for stresses in thin circular disks and the application of proper boundary conditions, the concept of a negative temperature distribution (a method of superposition used in stress analysis) that will represent the cooling leads to the conclusion that, under these conditions, the stress in the glass near the hole is independent of the temperature distribution around the hole and dependent only on the physical constants of the glass and the temperature of the lateral surface of the hole.

From author's summary

3029. Panasyuk, V. V., Podstrigach, Ya, S., and Yarema, S. Y., Heat stresses in a cylindrical shell (in Ukrainian), *Dopovidl Akad. Nauk URSR* no. 3, 231–234, 1955; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6866.

An analysis is made of the stresses arising in a cylindrical shell with unconstrained ends, under the effect of a temperature constant along the length and thickness of the envelope but variable along the periphery of the cross section. It is pointed out that the principal stresses are axial; for these, curves of the change in stress over the length of the shell and the contour of the cross section are given. Experimental data confirming the analysis are included. L. E. Andreeva

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3030. Meyer, J. H., Thermoelastic distortion and wing structural design, *Aero. Engng. Rev.* **16**, 9, 46–53, Sept. 1957.

Laboratory and flight-test programs involving structures at elevated temperature are reviewed. It is concluded that design methods suitable for elevated temperatures to 1200F are currently feasible. From author's summary

Experimental Stress Analysis

(See also Revs. 3008, 3031, 3070, 3253)

3031. Betser, A. A., and Frocht, M. M., A photoelastic study of maximum tensile stresses in simply supported short beams under central transverse impact, *J. appl. Mech.* **24**, 4, 509–514, Dec. 1957.

Stresses in beams under dynamic loading are receiving more attention by machine designers and experimentalists due to numerous transient conditions in modern machines. Authors use photoelastic model method, employing streak photography, to determine the maximum tensile stresses in short simple Castolite beams under transverse, central loads. Overhang on each beam had slight influence for the test conditions. Fringe intensity was proportional to the hammer velocity. For a span ratio of 3.4 to 5, maximum fringe intensity varied more sharply with the depth than the span; while for a span ratio larger than 5, the fringe intensity was influenced very much less. Depth varied from 0.5 to 2 in. and

the span varied from 3 to 11 in. Duration of impact was independent of impact velocity. Castolite is suitable for model impact studies. Elementary dynamic stress theory of simple beams for long spans agreed with dynamic photoelastic results, but it did not agree with results of span ratio less than 5.

An approximate dynamic theory is developed for short beams, using Wilson-Stokes theory. Authors assumed that dynamic deflections are the same shape as the static curves; that the deflection due to shear can be approximated; that the impact force rises instantaneously to its maximum value; and that all of the kinetic energy of the hammer is transferred into strain energy. Short-beam theory agreed well with dynamic photoelastic results. Article will enable the engineer to approximate dynamic beam stresses. H. Majors, Jr., USA

3032. Kuske, A., Contributions to the evaluation of photoelastic experiments on disks and plates in transverse bending (in German), *Forsch. Geb. Ing.-Wes.* **23,** 1/2, 16-21, 1957.

For Neuber's method of separation of principal stresses, in which the lines of constant principal stress sum are found graphically, some improvements are given and evaluation by new nomograms is proposed. Suggestions can be applied also to the two-layer method for plates, since analogy exists between plane stress and plate bending. E. Monch, Germany

3033. Riney, T. D., Photoelastic determination of the residual stress in the dome of electron tube envelopes, *Proc. Soc. exp. Stress Anal.* **15,** 1, 161-170, 1957.

3034. Baron, L. I., and Trumbacher, V. F., The application of the optical method for investigating the stress distribution in a medium influenced by pressure from an enclosed cavity (in Russian), *Vestn. Akad. Nauk KazSSR* no. 4, 65-74, 1955; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 7120.

An optical apparatus is described for the purpose indicated in the title, incorporating a pressure chamber. The isochromatic and stress curves are examined for varying positions of the pressure chamber.

Models are used to distinguish the different forms of initial breakdown of the medium with one or two exposed surfaces respectively. A. F. Rozhnyatovskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3035. Allsopp, H. L., Gibbs, D. F., and Wills, H. H., A sensitive electronic strain gauge, *J. sci. Instrum.* **34,** 8, 308-311, Aug. 1957.

A sensitive strain gage which was developed for investigating the electromechanical properties of ferroelectric barium titanate is described. It responds faithfully only to displacements occurring fairly rapidly, i.e., in less than about 1 sec. The lower limit of its response time is determined mainly by the mechanical system coupling . specimen to the gage, and is of the order of 1 ms. The limit of sensitivity is about 10^{-7} cm, but the sensitivity is variable over a wide range and absolute calibration is possible. The design allows the specimen temperature to be controlled over a range -150 to $+200°$ C. From authors' summary

3036. Bra,, J. W., An electrical analyser for rigid frameworks, *Struct. Engr.* **35,** 8, 297-311, Aug. 1957.

3037. McCoy, E. E., and Mather, B., Investigation of the improved Carlson stress meter, *Wwys. Exp. Sta. Tech. Rept.* 6-454, 27 pp. + 13 tables, May 1957.

The suitability of the improved Carlson stress meter for use in 6-in. aggregate concrete is evaluated. Four meters were tested in two 30- by 60-in. cylindrical concrete specimens. The concrete in one specimen contained aggregate graded to 1-½ in. in size, and in the other, to 6 in. in size. The specimens, which also contained strain meters, were subjected to several loading tests and were checked for creep, recovery, and the effect of temperature variation. Certain loading tests were conducted at the University of California. Results of the investigation indicate that the stress meters are sufficiently sentitive and independent of the effect of extraneous length changes for practical applications.

From authors' summary

3038. Theocaris, P. S., On strain rosettes and the stress gage (in Greek), Technicon Chronikon pp. 377-378, 1955.

3039. Theocaris, P. S., The use of electric strain gages for the determination of stresses (in Greek), Technicon Chronikon pp. 365-366, 1954.

Paper describes the use of electric resistance strain gages for the measurement of strains in two-dimensional stress fields. Among several types of strain gages, the electric-resistance wire strain gages are examined more extensively, and especially the bonded metallic gages.

The principles of operation of these gages are developed and their three characteristic sensitivity factors are defined. Formulas are given relating these factors with the measured strains and stresses.

Finally, some basic electric circuits used in electrical gaging operation are examined and formulas are given relating the measured potentials with the change of resistance in the gages.

From author's summary

3040. Shaitan, V. S., Strain gages for measuring hydrodynamic pressure under laboratory conditions (in Russian), *Tr. N.i in-ta osnovanii i fundamentov* no. 25, 85-101, 1955; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6801.

Selection of the principles of operation and the bases of design and construction of wire strain gages for measurement under laboratory conditions of small hydrodynamic pressures up to 150-200 g/cm^2 with a frequency up to 100 c/s. Gages of diaphragm and non-diaphragm type having an independent oscillation frequency of 400-800 c/s are examined.

Strain gages of diaphragm type may be found having stiff flat or corrugated diaphragms of steel, phosphor bronze, or beryllium bronze, German silver, etc. Non-diaphragm generators are more sensitive; the working beam which directly takes up the pressure is covered for protection against moisture by a freely fitting thin rubber membrane.

From the condition for obtaining increased sensitivity and a large natural frequency of the gages, author makes the following recommendations:

(1) The gages of the working beam should be selected according to the bridge arrangement with all four active shoulders.

(2) It is necessary to try to obtain the greatest increase of resistance of the gages and of the feed voltage of the bridge.

(3) The working beam (of high grade steel) should have two supports.

(4) The gages can be calibrated statically when the value of the ratio of the frequency of the measured pressures to the frequency of the natural oscillations does not exceed 1 : 6.

There is no mention of the stability of the zero of the gages and of the possibility of relaxation of the glue. Designs are given of the diaphragm and non-diaphragm strain gages, and also an instrument for their static calibration designed by the author.

N. A. Preobrazhenskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3041. Getz, J. R., Corrugated bulkheads I (in Norwegian), *Norges Tekn.-Naturvitensk. Forskningsrad. Byggetekn. Utwalg* no. 15, 97 pp., July 1956.

Deflection measurements have been taken on eight types of corrugated bulkheads—partly by the staff at S. F. I. and partly by the different shipyards' own staff.

The results have been analyzed and compared with calculated values. Due regard being taken of the accuracy of measurement and the uncertainty of boundary conditions, reasonable agreement has been obtained in most cases. In calculating the moment of inertia of the corrugation profile, the reduced effective flange width due to shear lag has been allowed for. In calculating the stiffness of webs and stringers placed across the corrugations on one side of the bulkhead only, the minimum height of the web has been used, and only a narrow flange (equal to 1/3 of the panel width) has been included on the bulkhead side.

Local deflections of the panels have not been studied, nor the stress distribution in corrugations and webs. The investigation has therefore been continued with laboratory experiments, which can greatly increase the accuracy of measurement and eliminate the uncertainty introduced by the complicated end conditions which often occur on board. From author's summary

3042. Getz, J., Torgersen, N., and Moen, K., Corrugated bulkheads II (in Norwegian) *Norges Tekn.-Naturvitensk. Forskningsrad. Byggetekn. Utwalg* no. 16, 70 pp., July 1956.

Tests have been conducted with two corrugated bulkheads, built in about 1/2 natural size. The corrugations are of trapezoidal shape, with 45° bending angle. The bending stresses and the deflections are accurately measured at a large number of points, and the results compared with calculated values.

Each bulkhead has been tested with the total length freely supported at the ends and with a reduced span with a constraining moment at the support.

Both the over-all behavior of the corrugated plate as a stiffener and the local behavior of the panels between the bends is shown to agree well with the theoretical prediction, effective flange width taken into account.

The stress distribution in a web plate across the corrugation, welded on one side of the bulkhead, is studied to some extent. From authors' summary

3043. Durelli, A. J., and Dally, J. W., Some properties of stresscoat under dynamic loading, *Proc. Soc. exp. Stress Anal.* **15,** 1, 43–56, 1957.

3044. McClintock, C. J., 17 ways of testing springs, *Prod. Engng.* **28,** 15, F36–37 (Design Digest Issue), Oct. 1957.

3045. Seary, W. W., Jr., Testing of railway passenger cars and components, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-111, 7 pp.

3046. Yegorov, A. S., An assessment of the influence of elastic deformation of tank bottoms on the filling ratio (in Russian), *Trudi Kievsk. fil. Vses. n.-i. in-ta spirt. prom-sti.* no. 2, 192–193, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7940.

An experimental method is presented for determining the mean bending deflection of the bottom, using a system of reference marks arranged on the tank bottom. E. I. Silkin

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Rods, Beams, Cables, Machine Elements

(See Revs. 2937, 2982, 2984, 2985, 2986, 2997, 2998, 3023, 3026, 3044, 3074, 3098, 3107, 3118, 3383)

Plates, Disks, Shells, Membranes

(See also Revs. 3017, 3029, 3062, 3063, 3078)

Book—3047. Alblas, J. B., Theory of the three-dimensional stress distribution in a plate pierced by a hole [Theorie van de driedimensionale Spanningstoestand in een doorboorde plaat], Amsterdam, H. J. Paris, 1957, xii + 127 pp. (Paperbound).

Book is concerned with the rigorous three-dimensional (classical) analysis of the elastic stress distribution when a plate pierced by a circular hole is stretched or bent. For stretching, the stress concentration factor at the middle plane does not exceed by more than 3% the value 3 given by the two-dimensional theory, whereas at the outer faces this factor can fall short by from 10 to 15%, Poisson's ratio being taken as ¼. As regards bending the author finds that the classical theory has only a limited value, while Reissner's theory gives a very good approximation for stress resultants but by no means for the stresses themselves; further, on the surface of the plate the full three-dimensional theory is alone trustworthy. The last chapter discusses in detail the Mathar-Soete method of evaluation of residual stresses, particularly the effect of plate thickness on the evaluation of strain-gage readings.

L. M. Milne-Thomson, USA

Book—3048. Hoeland, G., Influence surfaces for support bending moments in continuous plates [Stutzmomenten-Einflussfelder durchlaufender Platten], Berlin, Springer-Verlag, 19 pp. + 75 tables. DM 37.50.

Progress of theory in the field of applied mechanics is rapid; technical applications of results lag considerably behind. Everything that helps to bridge this gap is of real value. Book under review serves this purpose. [So far, only influence surfaces for single-span plates were known; e.g., E. Bittner, 1938; A. Pucher, 1938, 1951; W. Nowacki and J. Mossakowski, 1953 (annular sector), etc.]. Author gives very complete collection of graphs (75 tables, 21 × 30 cm) for computing bending moments over linear support of two-span continuous plates. Nearly all practically possible combinations of different boundary conditions and different system geometry are taken into consideration. Most of the tables (9–67) hold for fixed support; part of them however (68–75) are computed for continuous two-span plates carried on elastic middle support. All tables were calculated with Poisson's ratio $\nu = 0$.

The accompanying text is good and concise; the results of remarkable computational effort are presented in 75 clear and neat graphs, reproduced in comfortable scale.

A very useful book. W. Olszak, Poland

3049. Burghgraef, B., Simply supported rectangular plates subjected to the combined action of a uniformly distributed lateral load and compressive forces in the middle plane, *Inter. Shipbldg. Progr.* **4,** 39, 572–578, Nov. 1957.

A method to evaluate the maximum deflection and maximum stresses in a simply supported plate subjected to water pressure and compressive forces in the middle plane is discussed. Method is based on a comparison of the results obtained from Marguerre's theory and from Saint-Venant's linear equation for small deflections of plates. A magnification factor is derived by means of a similar procedure used by F. Bleich. However, a more accurate result is sought by taking into account a term neglected by Bleich.

Charts are given from which a rapid computation of maximum deflection and stresses may be made. Limitations on the use of the magnification factor are discussed and a numerical example is given.

In an appendix is a description of the method for preparing the chart from which the magnification factor can be determined. It is shown that a simple construction and only a minimum of numerical work are necessary.

Finally, some references are given.

From author's summary by C. Massonnet, Belgium

3050. Brotchie, J. F., General method for analysis of flat slabs and plates, *J. Amer. Concr. Inst.* **29,** 1, 31–50, July 1957.

A theory for analysis of moments, shears, and deflections in plates is outlined, and a method developed for its application to flat slab and flat plate structures. The slab is considered as floating on the surface of a liquid; each load and each reaction is applied separately to the floating slab, and these separate effects are summed to give actual moments, shears, and deflections in the structure. Theory is applicable to panels of any shape—square, rectangular, triangular, or trapezoidal—with any type of loading. The method allows for any degree of restraint of fixity between slab and column.

Application of the theory in this paper is limited to internal panels with known column reactions, and tables are presented for the quick determination of moment, shear, and deflection at any point of the panel. From author's summary

3051. Sen, B., Note on a direct method of solving problems of elastic plates with circular boundaries having prescribed displacement, *ZAMP* **8,** 4, 307–309 (Short Notes), July 1957.

3052. Kasab'yan, L. V., Computation of rectangular plates on an elastic monolayer basis (according to the theory of Professor V. Z. Vlasov) (in Russian), Avtoref. diss. kand. tekhn. nauk. Mosk. inzh.-stroit. in-ta, Moscow, 1956; *Ref. Zb. Mekh.* no. 12, 1956, Rev. 8482.

3053. Simmons, J. C., Shear moduli for flat panels and the effect of flange flexibility, *J. roy. aero. Soc.* **61,** 562, 696–700 (Tech. notes), Oct. 1957.

Book—3054. Girkmann, K., Plates and shells—introduction to the elasto-statics of thin slabs, plates, shells and prismatic structures [Flächentragwerke], 4th ed., Wien, Springer-Verlag, 1956, xix + 596 pp. $15.70.

The well-known manual of K. Girkmann, professor at the Technical University of Vienna, appears in the fourth edition, which may be considered as a sign of its great value and usefulness for students and engineers. After a short introduction into the problems of elasticity of two dimensions author presents many problems of thin slabs with various shapes and edge conditions. Additions have been made to former editions, giving closed solutions for several cases of boundary and loading conditions. Theory of circular slabs is amplified too, and application of single trigonometric series which simplifies computation of slabs is shown. The chapter on plates is extended in various directions, as for example in amplifying theory of plates supported by rows of equidistant columns (Pilzdecken) and in giving new solutions for the plate supported on two opposite edges. In the chapter "Membrane theory of shells" are considered new types of translation shells (solutions of E. Tungl). Computation of cylindrical shells is simplified for practical use by means of a new numerical example. Some amplifications of the chapter "Buckling of shells" are made, especially new results of experimental researches. Theory of prismatic structures is expanded in various directions, offering new solutions for continuous, polygonally shaped roofs and prismatic towers with tympans on the opposite ends. The well-known publisher has done his best to obtain clear and exact representation of formulas and diagrams.

Reviewer believes that this new edition represents an excellent completion of Girkmann's book, which will widen his circle of readers. H. Beer, Austria

3055. Morice, P. B., An approximate solution to the problem of longitudinally continuous shells, *Mag. Concr. Res.* **9,** 26, 95–104, Aug. 1957.

According to the similar form of the differential equation governing transverse vibrations of beams and of the Schorer equation for cylindrical, longitudinally continuous shells, author develops solution of the last problem in terms of basic functions used by Inglis for solving the mentioned vibration problems. Generally, by use of matrix notation, relations are treated between the shell actions and deflections; special attention is paid to membrane and simple edge beam solutions. In the conclusion it is stated that the outlined analysis appears to have all the computational advantages of the harmonic solution for simply supported cylindrical shells.

V. Kopriva, Czechoslovakia

3056. Zwick, S. A., Thermal stresses in an infinite, hollow case-bonded cylinder, *Jet Propulsion* **27,** 8, 1, 872–876, Aug. 1957.

An infinitely long, thick cylindrical tube is bonded at its outer surface to a thin cylindrical shell. The inner surface of the tube is thermally insulated and the temperature of the outer surface of the shell is suddenly changed. Axisymmetry of deformations is assumed and the ordinary thermo-elasticity equations are solved to obtain a quasi-steady-state approximate solution. The stresses found in both bodies correspond to the instantaneous temperature distribution. W. A. Nash, USA

3057. Haenle, S., Contributions to the strength behaviour of flanges with welded neck and to the evaluation of the scaling forces of some soft gaskets on an asbestos base (in German), *Forsch. Geb. Ing.-Wes.* **23,** 113–134, 1957.

Author proposes a slight modification of an existing, rather simple method for the stress analysis of welded flanges of tubes under internal pressure (the method is known in Germany as "VGB-Formula"). It considers among other things the pre-loading of the flange bolts. In an extensive test program, nine specimens with flanges of German and American standards have been investigated to evaluate strength, flexibilities, and deformations of these flanges. Furthermore, the required sealing forces for several soft gaskets have been determined and design values are suggested for several common configurations.

F. M. Mueller, USA

3058. Vlaszov, V. Z., and Garai, T., The condition of the kinematical indeterminacy of momentless shells of revolution (in Hungarian), *Magyar Tud. Akad. Oszt. Közl.* **19,** 1/3, 211–223, 1956.

Shells of revolution lose (under certain geometrical circumstances) their bearing capacity of holding external loads and permit small displacements. The paper deals with the determination of the geometrical conditions in the case of several shells.

J. Barta, Hungary

3059. Staats, G. P., Pressure-flange design, *Prod. Engng.* **28,** 23, 117–119, Dec. 1957.

Buckling Problems

(See also Revs. 3049, 3066)

3060. Hayes, J. M., Effect of initial eccentricities on column performance and capacity, *Proc. Amer. Soc. civ. Engrs.* **83,** ST6 (*J. Struct. Div.*), Pap. 1440, 41 pp., Nov. 1957.

Paper summarizes the results of tests made to study the effect of initial eccentricities upon column performance and capacity. The type of section investigated was the rolled H-section. The eccentricity was created by milling out-of-square about the weak axis the bearing ends at a partially riveted splice. The columns were all fabricated from ASTM A7 structural steel.

This type of eccentricity had only a small effect upon the capacities of the columns tested. It gave greater unit shortening and reduced the stiffness of the column. The capacity of the column may, in general, safely be considered equal to that of an identical unspliced column, provided that the Euler critical load, based on hinged-ends, is greater than the yield point strength of the material, and the ends of the column are, at least, partially restrained. From author's summary

3061. Vinokhurov, L. P., Stability of a spatial system of columns, the tops of which are joined by a rigid body (in Russian), *Trudi Khar'kovsk. inzh. stroit.-in-ta* no. 4, 147-154, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 1095.

An investigation is made of the torsional bending form of loss of stability in the rod system, appearing as spatially placed, parallel pillars of equal height, rigidly joined below to the foundation and hinged above to a rigid body (flat disk). An equation is given for the determination of the critical loading.

I. G. Popov
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3062. Shuleshko, P., Buckling of rectangular plates with one unsupported edge, *J. Instn. Engrs. Austral.* **29,** 9, 215-218, Sept. 1957.

The nondimensional buckling coefficient is calculated for a rectangular flat plate compressed by uniformly distributed forces normal to the edges in the plane of the plate. Two opposite edges are simply supported and the load on these has a constant ratio to the load on the other two edges, of which one is rigidly built-in and one is free. Results are presented in graphical form for several load ratios. M. Botman, Canada

3063. Vol'mir, A. S., On the influence of initial imperfections on the stability of cylindrical shells under external pressure (in Russian), *Doklady Akad. Nauk SSSR* (*N. S.*) **113,** 2, 291-293, 1957 (translated by M. D. Friedman, Inc., 67 Reservoir St., Needham, Mass., V-124, 5 pp.).

Paper is condensation of solution of complex problem of snap-through and postbuckling behavior of cylindrical shells subjected to uniform lateral pressure. Author uses approximate deflection function $w = f(\sin \alpha x \sin \beta y + \sin^2 \alpha x + \phi)$ which includes initial imperfection effects. Terms f and ϕ are deflection parameters. Total potential energy of system is expressed in terms of w and a stress function related to the middle surface of the shell. Ritz method is used to minimize potential energy. For various non-dimensional imperfection factors, a non-dimensional load parameter is plotted versus a non-dimensional deflection parameter for a shell with $R/h = 112.5$, $L/R = 2.2$, $\nu = 0.3$ (R is mean radius, h is thickness, L is length, and ν is Poisson's ratio). The lower bound on the load parameter remains practically independent of the imperfection factor. The lower bound computed by author agrees well with the lower bound computed for an ideal circular cylindrical shell by Langhaar-Boresi [See University of Illinois Bulletin 443, Snap-through and postbuckling behavior of cylindrical shells under the action of external pressure, Urbana, Illinois]. A series of experiments conducted on duraluminum shells by V. E. Mineev and author confirms theory. A. P. Boresi, USA

3064. Ma, B. M., Elastic structures with nonlinear load-deflection curves, *Proc. Amer. Soc. civ. Engrs.* **83,** ST6 (*J. Struct. Div.*), Pap. 1441, 40 pp., Nov. 1957.

By writing moment equations with respect to the deformed configuration, author obtains nonlinear load-displacement relations for a simple structure in the elastic range.

F. L. DiMaggio, USA

3065. Ivlev, D. D., Buckling of eccentric pipes (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 10, 112-116, 1956.

The linearized equations of the Mises theory of plastic flow are used to study the beginning of the formation of a bulge in a pipe of small eccentricity acted upon by an internal pressure. The elastic deformations are considered to be negligibly small in comparison with the plastic deformations. From author's summary

Joints and Joining Methods

(See Revs. 3010, 3282)

Structures

(See also Revs. 3005, 3019, 3036, 3037, 3061, 3064, 3094, 3099, 3107, 3119, 3282, 3344, 3382, 3389)

Book—3066. Shanley, F. R., Strength of materials, first edition, New York, Mc-Graw-Hill Book Co., Inc., 1957, xxii + 783 pp. $8.50.

Book differs both in presentation and scope from conventional textbooks on strength of materials. The presentation, in which "the author has been guided by the principles of general semantics, as developed by Korzybski and others," is highly unconventional. "The scope of the book has been expanded considerably beyond the usual limits for a text of this type." For example: the important concept of probability has been introduced in an elementary way; more attention is paid to inelastic behavior, buckling phenomena, fatigue of metals than is usual; dimensionless plotting of stress-strain curves, column curves, and interaction diagrams is discussed; and applications of results (without derivation) from advanced strength of materials and the theory of elasticity are frequently made.

The book is divided into three parts: Part 1, Forces and deflections, Stress and strain, 12 chapters; Part 2, Analysis of structural elements, 11 chapters; Part 3, Strength of structural elements, 5 chapters.

Some will find objectionable the author's use of certain terms and expressions. "Deflection" is used to denote not only deflection but such other concepts as displacement, deformation, elongation, rotation. It is not completely clear just what is meant by a "curved force." "Plane strain" is somewhat disconcertingly used to denote the state of strain accompanying plane stress.

W. R. Osgood, USA

Book—3067. Grassie, J. C., Analysis of indeterminate structures, New York, Longmans, Green and Co., Inc., 1957, viii + 418 pp. $9.75.

Book presents fundamental methods for the analysis of statically indeterminate structures. Included are the better modern developments as well as the so-called classical procedures. Examples chosen relate to structures encountered in bridges and buildings.

Problems with answers are given at the end of each of the seven chapters.

Order in which the topics are given is excellent. Author begins with the various methods for determining deflections and rotations and proceeds to develop analysis techniques. Modern tools including the conjugate beam ideas, moment distribution, column analogy and slope deflection are given, with application to the analysis of beam, bent and arch structures.

Indeterminate trussed structures and a brief discussion of secondary stresses in framed structures are included. The treatment of continuous and long span bridges of the moving type illustrates the use of influence lines, the theory of which was formulated in an earlier chapter of the book. Suspension bridges have been excluded, an omission clearly justified.

The concise manner in which the material is presented requires considerable independent study from the reader.

R. C. DeHart, USA

3068. Adam, C., Computing some special cases of store frameworks under horizontal load (in Dutch), *Tech. Wet. Tijdschr.* **27**, 1, 1-8, Jan. 1958.

Paper deals with regular cases of symmetrical, single-bay, multistory plane frames with rigid joints subjected to horizontal loads concentrated at the joints as in the usual treatment of wind loads. Story height is constant. Flexural stiffness of columns and of girders is in a fixed ratio at each story and forms geometric progression from top story to bottom. Two loading cases considered are single load at topmost level, and equal loads at each level.

Author uses slope-deflection approach which he attributes to Gehler but which is perhaps more properly attributed to Maney. General equations are reduced to single recursion formula involving unknown joint rotation at three successive levels which is a limited form of recursion formula obtained by reviewer more than twenty years ago [*Trans. Amer. Soc. civ. Engrs.* **102**, p. 922, 1937; *J. Amer. Conc. Inst.* **19**, p. 225, 1947]. Although author does not note correspondence of recursion formula to difference equation, solution is obtained by difference equation method with detailed expressions for evaluation of arbitrary constants. Reviewer suggests that additional loading cases may be readily handled by same method, e.g., linearly increasing concentrations.

Although method presented in paper has considerable academic interest (difference equation solution of this problem has been taught by reviewer for several years), reviewer believes that iterative solution is so simple and so much more general that it is preferable under normal circumstances.

J. E. Goldberg, USA

3069. Barnett, R. L., Influence diagrams for statically determinate structures, *Civ. Engng., N. Y.* **27**, 10, 81-82, Oct. 1957.

3070. Taylor, K. V., and Parker, M. N., The strength and stiffness of scalloped stiffeners determined by full-scale tests at Glengarnock, *Trans. Instn. Engrs. Shipb. Scot.* **101**, 1, 13-42, 1957-58.

An investigation into the effect of scalloping the webs of stiffeners upon the bending strength of stiffened panels of plating. Measurements of stresses and deflections were made for both plain and scalloped specimens of flanged plates and inverted angles, and the results have been compared. A pair of specimens was tested to destruction, and a comparison of the ultimate load-bearing capacity and manner of failure of plain and scalloped specimens obtained.

It appears that the cutting of scallops has no measurable effect on the maximum stress in a stiffener loaded within the elastic range, but deflection is increased for a given load. The scallops, however, reduce the stability of the section, and a scalloped specimen withstood only 75% of the load required to produce failure in a similar specimen with intact web.

From authors' summary

3071. Klein, B., Limitations of the finite difference method of structural analysis, *J. aero. Sci.* **24**, 10, 774-775 (Readers' Forum), Oct. 1957.

3072. Stern, E. G., Nailed trussed rafters for industrial and farm structures, *Virginia Polyt. Inst., Wood Res. Lab. Bull.* 33, 16 pp., Feb. 1958.

3073. Riley, W. E., Analysis of continuous arches on flexible piers, *J. Amer. Concr. Inst.* **28**, 10, 999-1012, Apr. 1957.

3074. Menn, C., Circular ring beam and winding surface (in German), *Mitt. Inst. Baustat., ETH, Zürich* no. 30, 124 pp., 1956.

Various new methods are developed for calculating the circular ring beam, the screw-line beam, the circular ring plate and the winding surface. For the first time the exact differential equation for rod-like carriers (circular ring beams and screw-like beams) has been derived with regard to the proposed approximate method for cantilevered winding surface. Whereas the static calculation of these carriers is based mainly on known statements for the solution, the areal beams (circular arch plate and winding surface) are treated by principally new and independent methods. Thus author has succeeded in stating an exact solution for the cantilevered and the clamped circular arch plate as well as for the infinite winding surface, whereas approximate solutions are given for varying support proportions of the finite winding surface.

Author emphasizes the possible simplifications for a certain shell problem, in order to get reasonable approximate solutions. He distinguishes between static simplifications (with regard to the slope of the stress in the cross section) and geometric ones (with regard to the curvature). The investigations show that this kind of simplifications depends mainly on the support conditions; e.g., a static simplification is only justified for a beam supported on both sides, whereas the geometric simplification is only restricted to beams supported on three and four points (according to the calculations of the winding surface).

M. Schafer, Germany

3075. Morgan, W. C., and Kemp, R. H., Design and experimental evaluation of a light-weight turbine-wheel assembly, *NACA TN* 4023, 10 pp. + 15 figs., June 1957.

3076. Oatul, A. A., The analysis of arches with continuous superstructure (in Russian), *Trudi Uralskogo politekhn. in-ta* no. 54, 44-68, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7833.

The arch with a continuous superstructure is regarded as a form of monolithic frame. The calculation method is founded on the technique of distributed constraining moments developed by S. A. Rogitsky ["Frame analysis," Mashgiz, 1948]. The distribution of the constraining moments is performed with simultaneous consideration of the influence of rotation and displacement of the joints.

E. I. Silkin

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3077. Bychkov, M. I., The safety factor in eccentrically stressed ferro-concrete structural components (in Russian), *Trudi Ural'skogo politekhn. in-ta* **54**, 117-125, 1955; *Ref. Zh. Mekh.* no. 12, 1956, Rev. 8654.

Using known formulas for calculation, author obtains an inequality $k_e/k_N \lesseqgtr 1$ where k_e is the safety factor through the eccentricity, k_N is the safety factor through the longitudinal force, the signs of inequality $<, >$ relate to the eccentric stress of the

first and second degree. Here two variants of rupture are examined: (1) the longitudinal force increases, while the eccentricity remains constant; (2) the longitudinal force does not change, while the eccentricity increases. Examples are put forward, and a short survey is given of the works connected with the coefficient of safety for eccentrically stressed ferro-concrete structural members.

N. S. Kurdin
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3078. Freiberger, W. F., On the minimum weight design problem for cylindrical sandwich shells, *J. aero. Sci.* **24,** 11, 847–848 (Readers' Forum), Nov. 1957.

3079. Şemonian, J. W., and Crawford, R. F., Some methods for the structural design of wings for application either at ambient or elevated temperatures, *Trans. ASME* **80,** 2, 419–426, Feb. 1958.

An orderly procedure for comparing structural configurations is presented, in which minimum required weight is evaluated as a function of loading magnitude. The method is applied to several box beam configurations in pure bending. Three classes of failure are considered: local buckling of cover plate, crushing of internal members, and general instability. Calculations are based upon analyses which are not included in the paper. Optimum choices of material and configuration are shown to depend on loading magnitude as well as on temperature-time condition. Thermal stresses are not considered quantitatively, but authors see no conflict between designing for thermal stresses and for minimum weight.

Under certain conditions, optimum design is obtained with complex configurations such as spanwise stiffened cover plates supported by corrugated chordwise ribs. The attachment problems will require investigation. L. Mordfin, USA

3080. Willis, J. G., Some notes on sandwich design for minimum weight as applied to airplane wings, *Aero. Engng. Rev.* **16,** 10, 44–47, Oct. 1957.

3081. Taylor, J. L., Stress in a curved skin panel of a pressurized fuselage, *Aircr. Engng.* **24,** 341, 216–218, July 1957.

3082. Halasz, O., On the limit design of reinforced-concrete plates (in Hungarian), *Magyar Tud. Akad. Oszt. Közl.* **19,** 1/3, 227–237, 1956.

Aim of paper is to determine limit load. The plate is simply supported. The steel bars are placed perpendicularly on each other. The train of thought differs from one of the fundamental theorems of the limit design theory, which says that the intensity of the limit load is intensity of that statically possible load, the bending moments of which are not greater than the limit bending moments. A detailed computation is executed for the rectangular plate. J. Barta, Hungary

3083. Symposium on prestressed concrete, *J. Instn. Engrs., India* **35,** 7 (part 1), 627–903, Aug. 1955.

3084. Best, C. H., Pirtz, D., and Polivka, M., A loading system for creep studies of concrete, *ASTM Bull.* no. 224, 44–47, Sept. 1957.

3085. Mohay, K., Determination of the anchoring-length of high-tensile wires, Festival issue of Publ. Techn., Univ. Budapest, Civ. Engng. Dept., 1957, 51–62.

The study refers to prestressed reinforced-concrete structures. Experiments and measuring results are described. These lead to the conclusion that the anchoring length may be estimated as 10 inches for fluted wires and as 15 inches for corrugated wires. The diameter of the wires was 0.196 inch. The numerical evaluation is based on Guyon's theory. J. Barta, Hungary

3086. Turner, F. H., Estimating the size of rectangular sections, *Concr. constr. Engng.* **52,** 7, 233–236, July 1957.

3087. Szeremi, L., Wind load analysis of reinforced-concrete arch bridges of continuous type (in Hungarian), Epitoipari es Kozl. Musz. Egyetem. Tud. Kozl. **2,** 2, 19–66, 1956.

To avoid the cumbersome process of the classical method, author uses the moment distribution method. Hereby several simplifications due to P. Csonka are applied.

J. Barta, Hungary

3088. Lepajne, S., Simplified analysis of bridge arches rigidly connected with the upper structures (in Slavonian), *Gradbeni Vestnik* no. 45/46, 87–91, 1956/1957.

Thorough study was made in connection with the Lesce-Bled bridge across the Sava River. Author uses fundamental methods of distributing the bending moments in the arch and the spandrel structure in accordance with the stiffness of individual members. Influence lines for vertical loads are developed for full and partial restraint of the arches. It is first assumed that the moments of inertia of the arch and the spandrel beam follow equal variation, and additional corrections are introduced.

J. J. Polivka, USA

3089. Gamayunov, A. I., Determination of the pressure of ice on the buttresses of bridges (in Russian), *Zb.-d. str.-vo* no. 4, 23–25, 1955; *Ref. Zh. Mekh.* no. 12, 1956, Rev. 8645.

The results are given of the theoretical and experimental investigation of ice pressure on the ice-breakers. The ice moving up the sloping edge of the ice-cutter gives rise to horizontal and vertical pressures, reaching their maximum at the moment of the splitting up of the ice. The ice field is looked upon as a thin infinitely large slab with an elastic foundation. The problem is evolved of the local bending of this slab under vertical forces corresponding to the vertical components of the pressure exercised by the ice on the ice-cutter. The limiting value of this pressure is determined from the condition of the equality of the maximum bending moment in the slab to the production of the moment of resistance of the ice slab on the boundary of the stability of the ice to bending. The formulas submitted are designed for the determination of the magnitude of the vertical and horizontal ice pressures when using various forms of ice cutters.

S. A. Sementsov
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 3000, 3024, 3027, 3079, 3084, 3236)

3090. Kornilov, I. I., A high-temperature centrifuge for creep, rupture, and bend tests, *J. Metals* **10,** 3, 187–189, Mar. 1958.

Author describes creep testing machine for bend tests, in which centrifugal force is used and in which 24 test pieces may be tested simultaneously at temperatures up to 1200 C for short-time as well as for long-time tests up to 10,000 hr. Method is recommended for rapid testing of large number of small specimens in studying influence of temperature and metallurgical variables. Phase diagrams, based on creep properties for Ni-Cr system, are included. No indications of how to correlate results with those of ordinary creep tests in tension are given.

F. K. G. Odqvist, Sweden

3091. Creep design workshop, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-286, 13 pp.

3092. Pian, T. H. H., On the variational theorem for creep, *J. aero. Sci.* **24,** 11, 846–847 (Readers' Forum), Nov. 1957.

3093. Oding, I. A., A critical review of some theories of the creep of metals (in Russian), Problems of the metallurgy of boiler and turbine materials, Moscow, Mashgiz, 1955, 7–37; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6901.

Some theories of the one-dimensional creep of pure metals and high-temperature alloys are examined. It is indicated that the equations for one-dimensional creep can be arrived at in two ways: (1) By selecting empirical expressions on the basis of experimental data; (2) by deducing the creep equations from the different hypotheses of the mechanism of creep, with subsequent verification of the resulting equations by experimental data.

First, the author briefly surveys the existing empirical formulas for decaying creep, put forward by Endred, Ros and Eichinger, Weaver, Söderberg, Bailey, Rabotnov, Lacombe, Schwenar and Laurent. He points out that not one of these empirical fomulas has found any wide application in the analysis of the process of metal creep.

A more detailed examination is made of the theories founded on the different hypotheses of the mechanism of creep; the dislocation theory (Orowan, Smith, Motta and Wabarro), and the diffusion theory. In the author's opinion, the equations of one-dimensional creep obtained on the basis of dislocational conceptions satisfactorily describe the process of decaying creep in high-temperature alloys only in the presence of high stress values and relatively low temperatures.

Some theories are further reviewed of the phenomenon of established creep, and the question is discussed of the relationship between a steady rate of creep and temperature, under constant stress.

It is pointed out that there is not, at present, any generally acknowledged functional relationship between stress and steady creep, or steady creep and temperature.

No bibliographical references are given.

F. S. Churikov
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3094. French, F. W., Jr., Patel, S. A., and Hoff, N. J., Creep deformations of rectangular frames, Polyt. Inst. Brooklyn., Aero. Lab. Rep. 340, 24 pp. + 14 figs., July 1957.

Report has as its purpose the theoretical and experimental investigation of the behavior of rectangular frames subjected to loads at high temperatures. The effect of the creep deformations upon the stress distribution in the structure is investigated. The analysis ignores the elastic deformations and the primary creep and takes into consideration only the steady creep. Use is made of the moment-curvature law of the nonlinear elastic material. The beam-column action is investigated and is found to be negligible; also the effect of the clamped ends. As creep deformations take time, at first the deformations are elastic. After a sufficiently long time the moment distribution approaches asymptotically that corresponding to fully developed steady creep. The steady-creep rates are determined from experiments. Comparison of the predicted and observed displacement rates shows satisfactory agreement.

L. Foppl, Germany

3095. Isaksson, A., Bibliography on creep under variable stress and temperature with comments (in Swedish), Kungl. Tekniska Hogskolan, no. 116, 43 pp., June 1957.

3096. Matveev, S. I., Method of testing for creep in models of turbine disks (in Russian), Vopr. metalloved. kotloturbinnykh materialov, Moscow, Mashgiz, 1955, 86–103; *Ref. Zh. Mekh.* no. 12, 1956, Rev. 8520.

A short description is given of machine TsNIITMASH selected for experiments on creep in models of disks when rotated at temperatures between 300 and 650°. The method is given for the determination of stresses in the disk when creep is operating, and also the results for three model disks, prepared from different steels and methodically examined. It is recommended that stresses in the disk at the end of its period of test in the machine should be determined as the sum of the elastic stresses and residuals. The latter are found by the known method based on the measurement of the external diameter of the disk in the process of the laminar boring of the central hole of the disk.

The methodical testing of the models of disks showed the principal suitability of the described method; however the cited diagrams of stresses, obtained when working on the results of the measurements, apparently differ from the actual.

A. G. Kostyuk
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3097. Russanova, E. I., The theoretical principles of the calculation of machinery parts working at high temperature (in Russian), *Trudl Vses. nauch. inzh.-tekhn. o-va sudostroyeniya* **6,** 3, 66–89, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7762.

The creep equations embodying the creep modulus and modulus of hysteresis are written on the assumption that, at stress values not above the flow limit, the three-dimensional, creep defomation develops elastically, while the defomation of change of form is composed of an elastic shear deformation and a deformation due to hysteresis and relaxation.

The problem is examined of the determination of the creep modulus from experimental tests for univalent creep, and the relationship between the moduli of creep and hysteresis is defined. The conditions of creep failure are briefly considered.

F. S. Churikov
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3098. Fuks, M. Ya., and Glazyak, I. K., The sag of turbine shafts and rotors in the high-temperature test (in Russian), *Vestnik mashinostroyeniya* no. 6, 30–34, 1955; *Ref. Zh. Mekh.* no. 1956, Rev. 7952.

To determine the ability of turbine shafts and rotors to maintain rectilinear axes when heated, they are tested at elevated temperature.

In the majority of cases the test forgings exhibit a transient bending distortion with increasing temperature, but this diminishes to an acceptable value when the state of "isothermal anneal" (period during which the temperature is uniform over the whole cross section of the forging) has been reached.

The results of x-ray examinations are presented of the scale formed on the machined test bars after heating to 650°, and the investigation of the effects of removing the scale coating on machined billets when heated to 650°; also an investigation into the influence of the surface condition of steel sample bars on their capacity for absorbing radiant heat is reported.

Further, results are given of experimental heating tests of shaft blanks in electric furnaces, arranged to investigate the influence of repeated machining and surface condition on the temporary bending deflection of shafts.

From these experimental results, the assumptions of Weaver [*Gen. Elect. Rev.* **44,** 10, p. 543, 1941] are disproved, that the decreasing flexure of a shaft in heat testing can be explained by straightening of the forging owing to balancing of the thermal conductivity of the surface layer by the effect of recrystallization.

It is further concluded that the transient warping experienced in heat tests conducted by usual methods is not associated with the quality of the forging, but is caused by axial symmetry and the

temperature distribution across the section, due to the variation in the degree of scale formation of individual regions of the surface.

In order to render the scale formation on the surface of the shaft more uniform, it is recommended to coat it with 302 varnish in admixture with 20% aluminum powder; with this treatment, transient warping decreases to a fraction of the original value and falls below the accepted standard (< 0.05 mm).

It is pointed out that the purpose of such high-temperature tests is the determination of the degree of flexure remaining constant throughout the period of "isothermal anneal," and the residual warping remaining after cooling of the casting.

The appearance of a constant flexural distortion can be explained by axial asymmetry in the distribution of the coefficient of dilatation across the section of the forging, while the residual distortion is due to the presence in the forging of residual axial stresses, distributed asymmetrically to the axis.

A. D. Kovalenko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3099. Mathauser, E. E., Berkovits, A., and Stein, B. A., Recent research on the creep of airframe components, *NACA TN* 4014, 12 pp., July 1957.

3100. Bailey, W. H., Gemmill, M. G., Kirkby, H. W., Murray, J. D., Jenkinson, E. A., and Smith, A. I., Creep properties of austenitic nickel: chromium steels containing niobium, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-254, 9 pp.

3101. Mathauser, E. E., and Deveikis, W. D., Investigation of the compressive strength and creep lifetime of 2024-T3 aluminum-alloy plates at elevated temperatures, *NACA Rep.* 1308, 14 pp., 1957.

[See AMR **9**, Rev. 1456.]

3102. Dollins, C. W., and Betzer, C. E., Creep, fracture, and bending of lead and lead alloy cable sheathing, *Univ. Ill. Engng. Exp. Sta. Bull.* 440, 44 pp., Nov. 1956.

3103. Manukyan, M. M., Stresses due to shrinkage in symmetrically reinforced ferroconcrete elements with reference to the nonlinear creep of concrete (in Russian), *Izv. Akad. Nauk ArmSSR, Ser. fiz.-matem., estestv. i tekhn. Nauk* **7**, 3, 19–32, 1954; *Ref. Zh. Mekh.* no. 12, 1956, Rev. 8523.

An examination is made of the appearance and development of stress, appearing at times as the result of shrinkage of concrete in symmetrically reinforced ferroconcrete elements with reference to the nonlinear creep of concrete. External loading is not taken into account. The measure of shrinkage creep of concrete, as also the function characterizing the nonlinear relationship between the stresses and deformations of creep, is taken to be in the form advocated by N. Kh. Arutyunyan ["Some questions on the theory of creep," Moscow, 1952]. The function $f(\sigma) = \sigma + \beta\sigma^2$ with the small parameter β expresses a weak nonlinearity of this bond.

The integral equations of the examined problem merge with the nonlinear differential equations of the second order with variable coefficients. A simplification of the equations is effected by assuming a constant modulus of instantaneous deformation for concrete. Taking into account the initial conditions, a final generalization of Rikkat's equation is made.

An analysis is performed of the solutions depending on the relation of the parameters characterizing the intensivity of the shrinkage and creep of the concrete. The results of the calculations, which have been tabulated, show that, depending on the "percentage" of reinforcement, the stresses which have arisen in the concrete and reinforcement increase rapidly in the first two- or three-month period and then tend to stabilize. In calculating nonlinear creep, these stresses may be approximately 50% larger than in the case of linear creep, and increase together with the increase in parameter β.

W. Olszak

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3104. Kunin, N. F., and Svirsky, M. S., The problem of stress relaxation in metals (in Russian), *Trudi Chelyabinsk. in-ta mekhaniz. i elektrifik. s.kh.* no. 5, 127–133, 1955; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6910.

The change in stress by plastic deformation (in consideration of the processes of strain-hardening and recovery) is assumed to be expressed by the relationship $d\sigma = b\sigma\,(dl/l) - a\sigma\,dt$ [*] where $a = (\sigma - \sigma_s)\,a_0$, for $\sigma_s < \sigma < \sigma_c$, a = const, for $\sigma > \sigma_c$, in which l = length of sample, b coefficient of strain hardening, a coefficient of recovery, depending on the stress, σ_s elastic limit of the material before strain-hardening.

Proceeding from e.g. [*], authors develop for the relaxation case ($dl = 0$), the stress equation

$$\sigma = \frac{\sigma_s\sigma_0}{\sigma_0 - (\sigma_0 - \sigma_s)\exp(-\sigma_s t \tan\varphi_c)}$$

For σ = const, the known equation of internal friction applies.

S. A. Shesterikov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3105. L'Hermite, M. R., What do we know about the plastic deformation and flow of concrete? (in French), *Ann. Inst. tech. Bât. Trav. publics* no. 117, 778–810, Sept. 1957.

Author has analyzed, from his abundant documentation, a hundred French and foreign publications which have appeared during the past forty years. As a result of his own considerable work during the past twenty years, still in progress, he has succeeded in crystallizing an easily understood synthesis on the present state of the important and difficult problem of the plastic deformation and creep of concrete.

Author's conclusions are of direct use by engineers or builders, although a systematic study of the problem may not be possible.

The effects of the composition of the concrete, of the method of conservation, of the volume under stress, the age of the concrete, the importance and duration of the loading and unloading are also considered. The creep under different stress conditions is also examined. The creep is an hydro-constrictive phenomenon dependent upon the movements of the water; it is covariant with the shrinkage. The state of deformation tends towards a value proportional to the stress with a minimum corresponding to the shrinkage. The deformation follows a law similar to that for viscosity

$$\frac{d\Delta}{dt} = (\Delta_m - \Delta)\,K(a,t)$$

The rate of creep appears to reduce proportionally as the volume required increases.

Testing and measuring apparatus are described and numerous experimental results are presented which give to this publication an essentially reliable character. A theory is proposed, after dealing with other theories, and is presented in an impartial and objective manner, rather to satisfy the demands of those engaged in research and in experiment than to give a theoretical conclusion on the problem.

From author's summary

3106. Chechulin, B. B., Study of the micro-nonuniformity of the plastic deformation of steel, *NACA TM* 1411, 21 pp., Aug. 1957.

In 1949, Pashkov showed experimentally the enormous variation in strain from point to point in a polycrystalline metal. These

large deviations from the mean strain are believed to have important effects upon the strength and flow characteristics of a metal. This work is continued in the present paper, in which the author presents a new statistical method for the study of nonuniform strains. By means of frequency diagrams of the axial inequality of the grains of a polycrystalline metal before and after loading, the average deviation of the strain from the mean can be determined. By this method it is shown that steel with an austenitic structure undergoes strains which differ much less from the mean than steels with ferritic or pearlitic structure. In the latter case, the deviations from the mean increase continuously with the mean strain.

From author's summary

3107. Konishi, I., and Shinozuka, M., A consideration on the safety of structure by plastic and statistical theory (II), Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 193–196.

When a succession of live loads, each of which is less than the collapse load, is applied to a statically indeterminate beam, the failure of the beam is assumed to occur when the cumulative plastic hinge rotation reaches a certain value. Paper deals with the computation of this hinge rotation when the sequence of applied live loads follows a statistical distribution function.

M. Pei, USA

3108. Merz, E. H., and Colwell, L., A high shear-rate capillary rheometer for polymer melts, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-211, 5 pp.

An instrument has been developed to measure the flow characteristics of polymer melts at shearing rates over the range 1–10,000 reciprocal seconds and over the temperature range 70–700 F. The derived flow parameters are independent of capillary length and diameter. The application of some results obtained with this rheometer to polymer-processing problems is discussed.

From authors' summary

3109. Fredrickson, A. G., and Bird, R. B., Non-Newtonian flow in annuli, *Indust. Engng. Chem.* **50**, 3, 347–352, Mar. 1958.

Thermal diffusion has interesting potential applications in industry. This study shows, for example, how it can be used to separate certain esters and to bleach many types of chemical mixtures.

From authors' summary

3110. Metzner, A. B., and Otto, R. E., Agitation of non-Newtonian fluids, *AIChE J.* **3**, 1, 3–10, Mar. 1957.

Since the shear rate of a non-Newtonian fluid is of importance in fixing the rheological or viscometric behavior of such a material, the present study has been concerned with the development of a general relationship between impeller speed and the shear rate of the fluid. The resulting relationship was then used to interpret and correlate power-consumption data on three non-Newtonian fluids by use of a generalized form of the conventional power-number—Reynolds-number plot for Newtonians.

Flat-bladed turbines from 2 to 8 in. in diameter were used exclusively. Tank diameters ranged from 6 to 22 in. and power inputs from 0.5 to 176 hp/1000 gal. The study encompassed a 130-fold range of Reynolds numbers in the laminar and transition regions. The results to date indicate that power requirements for the rapid mixing of non-Newtonian fluids are much greater than for comparable Newtonian materials.

From authors' summary

3111. Lifson, S., The stability of jets of viscoelastic gels (in English), *Bull. Res. Counc. Israel* **6A**, 2, 119–124, Jan. 1957.

The stability of linear jets of viscoelastic gels streaming through air is found to be dependent on their elastic coefficient. The viscosity has no influence on the stability, but it damps the rate of divergence of unstable jets. The critical velocity for the jet, above which it becomes unstable, is calculated as a function of the elastic coefficient, the density of the surrounding medium, the thickness of the jet, and the wave length of the disturbance.

From author's summary

Failure, Mechanics of Solid State

(See also Revs. 2975, 3030, 3309)

3112. Uryu, T., Fatigue strength of notched carbon steel specimen with a circumferential crack at the notch root, *Rep. Res. Inst. appl. Mech. Kyushu Univ.* **5**, 20, 129–141, 1957.

Paper deals with rotary bending fatigue strength of annealed carbon-steel specimens having deep hyperboloidal section circumferential grooves of varying root radius combined with circumferential cracks. These latter were produced by high stress rotary bending (ca 2×10^5 cycles to cracking) followed by reannealing. Fair correlation is obtained with Neuber's [Kerbspannungslehre, Berlin, 1937] method for the deep hyperboloidal groove using an empirical relation that the crack is equivalent to such a groove of root radius $\rho_c = (\rho - \epsilon_c)\exp(-2(\lambda_c\rho^{1/2}) + \epsilon_c$ where ρ = original groove root radius, λ_c maximum crack depth and ϵ_c is a characteristic linear dimension of the plastic region near the crack. Suitable values of ϵ_c were 0.045 mm (1.8×10^{-3} in.) for 0.412%C steel, and 0.085 (3.3×10^{-3} in.) for 0.23%C steel. These values are a measure of the bending fatigue notch sensitivity of the materials.

E. M'Ewen, England

3113. Herzog, A., Fatigue testing of turbine buckets, *Proc. Soc. exp. Stress Anal.* **15**, 1, 21–34, 1957.

3114. Swets, D. E., and Frank, R. C., Fatigue life as a function of surface conditions, *Metallurgia, Manchr.* **56**, 337, p. 230, Nov. 1957.

Material Test Techniques

(See also Revs. 2975, 3008, 3066)

3115. Rao, K. R., An apparatus for the determination of the dynamic modulus of elasticity and logarithmic decrement of concrete and other building materials, Proceedings of the First Congress on Theoretical and Applied Mechanics, Nov. 1–2, 1955, 143–152; Kharagpur, Indian Inst. of Technology.

3116. Gillemot, L., edited by, Nondestructive material testing in iron and metal industries (in Hungarian), *Magyar Tud. Akad. Oszt. Közl.* **16**, 2/4, 1–468, 1955.

3117. Satyanarayana, B. S., A note on the measurement of Vickers hardness indentations, *Canad. J. Technol.* **34**, 5, 375–377, Sept. 1956.

3118. Bobrov, A. G., Apparatus for the testing of weak springs for torsion (in Russian), *Zavod. Lab.* **22**, 5, 617, 1956; *Ref. Zh. Mekh.* no. 12, 1956, Rev. 8683.

3119. Neville, A. M., The failure of concrete compression test specimens, *Civ. Engng., Lond.* **52**, 613, 773–774, July 1957.

Mechanical Properties of Specific Materials

(See Revs. 3022, 3066, 3072, 3095, 3100, 3101, 3102, 3103, 3105, 3106, 3115, 3268)

Hydraulics; Cavitation; Transport

(See also Revs. 2969, 3131, 3220, 3237, 3372)

Book—3120. Rouse, H., and Ince, S., History of hydraulics, Iowa City, Iowa, State University of Iowa, Institute of Hydraulics Research, 1957, xii + 269 pp. $5.

There exists no adequate history of fluid mechanics in any language. The work of Rouse and Ince is a valuable step toward constructing a part of such a history; every student of mechanics should consult it. It is written in a popular style, designed to appeal to the working engineer with little or no previous experience in the history of science.

There are many figures illustrating old hydraulic systems and experiments. Chapters on practical hydraulics in early antiquity, on Greek concepts of fluid behavior, on Roman water-supply systems, and on the mechanics of the middle ages convince the reader that hydraulics is a solid and ancient science. Since roughly half of the book is devoted to developments before 1800, the authors are able to deal more fairly with old researches than is often the case in general histories.

The descriptions of experiments are more enlightening than the summaries of theory, but that the authors attempt to include in a work of this kind so many mathematical researches, formerly taken lightly by hydraulic engineers, is extraordinary. When it is possible to do so, the authors keep experiment and theory together. Every page reflects the opinion they finally express on p. 244: "The most profound (recent) change of viewpoint has been the acceptance [by engineers] of the very methods that originally caused the rift between mathematicians and engineers . . ."

In line with this view, the contributions of Boussinesq are treated justly, perhaps for the first time in the hydraulic literature, and the later work of Reynolds is reduced to its due proportion. Many hydraulic engineers will be pleased to be able to read in English Daniel Bernoulli's own words describing the reasoning by which he groped to an incomplete form of what is now called "Bernoulli's theorem." This chapter and its predecessor on the mechanics and mathematics of the 17th century give a fairly representative picture of the kind of research done but are not accurate in detail, since the authors' opinions here derive at least in part from secondary works rather than from the original papers. It seems particularly unfortunate that while Euler's reaction turbine is described, there is no preceding discussion of the hydraulic (not hydrodynamic) theory that led up to it. The reader of this book will not learn that practically the entire body of modern theoretical hydraulics neglecting friction derives from papers written by Euler about 1750 and was carried into the German engineering literature through the textbooks of Kaestner (1769, 1797) and Brandes (1805) [*cf.* J. Ackeret, "Introduction to L. Euler's opera omnia," series II, vol. 15, Zurich, 1957].

From this history the practising engineer should learn more of the methods really used by scientists and research engineers than he is likely to gain from any textbook of the subject.

C. Truesdell, USA

3121. Alexander, G. N., Flood flow estimation, probability and the return period, *J. Instn. Engrs., Australia* **29,** 10/11, 263–280, Oct./Nov. 1957.

Author re-examines statistical methods of flood-flow forecast. These methods, based on probability curves extrapolation, were introduced some 30 years ago and, unfortunately, have been condemned after several failures, probably caused by improper application of inadequate data. Another approach—of maximum possible precipitation—often gives exaggerated results due to the compounding of unlikely events. Author explains some misleading statements against probability methods and assures that appropriate statistical procedures will be developed, outmoding the unsatisfactory and inconsistent practices of the present day. Article is illustrated with examples for Australian drainage areas.

S. Kolupaila, USA

3122. Rabkova, E. K., The movement of flood waters (in Russian), *Gidrotekhnika i melioratsiya* no. 12, 14–23, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 734.

Author has made an attempt, by means of laboratory experiment, to investigate some problems in connection with the hydraulics of turbulent flood-water flows (in accordance with the terminology of the third All-Union conference on flood water flows), representing in themselves a water stream, loaded to a pulpy condition with small particles of earthy matter, sand, shingle and stones. The study has to be looked upon as an experimental investigation of the movement of ordinary pulp with restricted limits, adopted by the author, for saturation of the stream with solid material. Deductions were made to the effect that the investigations made under laboratory conditions of the flow showed that the flow had a greater velocity when combined with a silted bottom, produced by a reduction of projections causing physical roughness, which in turn diminished resistance to flow and led to the levelling off of the distribution of velocities in the vertical plane, more especially in the immediate above-bottom region.

M. S. Gagoshidze

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3123. O'Connor, D. J., The mechanism of reaeration in natural streams, *Proc. Amer. Soc. civ. Engrs.* **82,** SA 6 (*J. san. Engng. Div.*), Pap. 1115, 30 pp., Dec. 1956.

The basic theory of turbulent flow has been applied successfully to explain many phenomena occurring in natural and artificial waterways. In this study, turbulent flow theory, both isotropic and nonisotropic, has been utilized to formulate the theory of reaeration in natural streams, which have been subjected to deaeration by the biological oxidation of organic matter. The general differential equation of the oxygen balance in a river is accepted as the basis for the analysis and a theoretical derivation of the reaeration coefficient is presented. Experimental work on reaeration under turbulent conditions was conducted to verify the theoretical development. Field data from sanitary river surveys are presented to show the comparison between the theoretically calculated and the observed values of the reaeration coefficients. Both this comparison and the experimental work substantiate the derived formulas.

From author's summary

3124. Obrazovskii, A. S., Application of a graded dependence to the building of a model for the structural mechanism of an open turbulent stream (in Russian), *Trudl gidravl. labor. Vses. n.-i. in-ta vodosnab., Kanaliz., Gidro-tekhn. sooruzh. i inzh. gidrogeol.* no. 4, 89–118, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 684.

On the basis of the presence of a free (without pressure) turbulent stream of ascending and descending flows, author sets up a structural (schematic) model of a similar stream, dividing it into a system of longitudinal vertical sections, in which alternately one contains only ascending and the next only descending currents. Viewed hydrodynamically such alternation is inconceivable, as in the spaces between contiguous ascending and descending layers circulations must be established (with longitudinal axes). In addition, it is known from direct observation that alternation of ascending and descending currents takes place along the stream and not transversely to it. Author determines the field of the ascending and descending currents from the very

diffuse stepped dependence $U = U_0\eta^n$. This corresponds sufficiently well with the real profile velocity (except for points near the bottom). Notwithstanding the border conditionality of the model it gives, in some connections, approximate convergence with the experimental. Author shows that the idea for this model belongs to the late N. M. Bernadskii. M. A. Belikanov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3125. **Cohen, H., Sutherland, C. D., and Tu, Y.-O., Wall effects in cavitating hydrofoil flow,** *J. Ship. Res.* 1, 3, 31-39, 50, Nov. 1957.

A linearized version of the transition-flow cavity model is used to obtain the effects of solid channel walls on cavitating hydrofoils. The formulation is in terms of two-dimensional flow but includes any shape hydrofoil within the scope of the linear theory and any location of the foil between the walls. The case of the flat plate foil is considered in numerical details. Three special cases of position, the foil midway between walls, near to only one wall, and the foil in an infinite stream (walls infinitely far apart), are taken up. The effect of the walls on lift and cavity length are discussed for each case.

From authors' summary by T. P. Torda, USA

3126. **Knapp, R. T., Cavitation and nuclei,** ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-80, 10 pp.

3127. **Reid, R. C., Reynolds, A. B., Diglio, A. J., Spiewak, I., and Klipstein, D. H., Two-phase pressure drops in large diameter pipes,** *AIChE J.* 3, 3, 321-324, Sept. 1957.

3128. **Karev, V. N., Mechanisation and automation of experimental investigations of the hydraulic resistances of a system of pipes** (in Russian), *Neft. kh-vo* no. 3, 55-56, 1956; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6606.

Incompressible Flow: Laminar; Viscous

(See also 2941, 2972, 2973, 3111, 3123, 3128, 3174, 3177, 3178, 3186, 3200, 3201, 3209, 3219, 3221, 3228, 3234, 3237, 3291, 3325, 3326, 3328, 3330, 3333, 3334, 3336, 3337, 3338, 3339, 3342)

3129. **Levenspiel, O., Longitudinal mixing of fluids flowing in circular pipes,** *Indust. Engng. Chem.* 50, 3, 343-346, Mar. 1958.

Design charts incorporating data from the literature can be applied to pipeline studies and design of chemical reactors.

From author's summary

3130. **Maennel, E., Study of a theory of a mechanical system obeying two different laws of friction: Application to the changes of regime of flow in pipes** (in French), *Ann. Ponts Chauss.* 127, 5, 549-597, Sept.-Oct. 1957.

One of the odd phenomena encountered in fluid mechanics is the change of regime of flow in pipes, which presents a complex theoretical aspect, although quite definitely established by experiment. The laminar regime encountered at low speeds and the turbulent regime met at high speeds are joined by a transition zone in which there appears transfer from one regime to the other. Author attempts to treat this problem by presenting a function whose extremes correspond to the laws of Poiseuille and Blasius. Presentation is nebulous. G. Power, England

3131. **Simosaka, M., and Oki, I., Abnormal friction loss in cast iron pipes of small sizes. The first report,** Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 345-348.

3132. **Wilbur, S. W., An investigation of flow in circular and annular 90° bends with a transition in cross section,** *NACA TN* 3995, 32 pp., Aug. 1957.

3133. **Kudsk-Jorgensen, B., Calculation of time-concentration curves in a stationary, laminar liquid flow through a circular-cylindrical tube,** *Acta Polyt.* no. 233, 17 pp., 1957.

Paper derives theoretical spreading behavior for a dye with negligible diffusivity introduced into a laminar Poiseuille flow. Results are compared with two experiments on flow in blood circulating systems. Reviewer finds theory largely duplicates special cases studied by many others in a more general framework. For example, P. V. Danckwerts [*Chem. Engng. Sci.* 2, 1, 1953] gives a more concise and satisfying treatment of this same problem. J. J. Van Deemter et al [*Appl Sci. Res.* (*A*) 5, p. 374, 1955] show how radial molecular diffusion alters the problem, finally leading to G. I. Taylor's better known solution for fast diffusion (or long tubes) [*Proc. roy. Soc. Lond.* (*A*) 219, p. 186, 1953; (*A*) 225, p. 473, 1954]. Experiments are interesting but deviate sufficiently from the theoretical curves to cast doubt on the author's assumption of Poiseuille flow through branching systems.

R. R. Hughes, USA

3134. **Pattantyus, A. G., Pneumatic conveying** (in Hungarian), *Magyar Energiagazdaság* 9, 11/12, 444-451, Nov./Dec. 1956.

3135. **Noll, W., On the rotation of an incompressible continuous medium in plane motion,** *Quart. appl. Math.* 15, 3, 317-319 (Notes), Oct. 1957.

3136. **Otuka, S., A theory about the secondary flow in cascades (The 15th report of study of axial-flow turbomachine),** Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 327-332.

3137. **Levine, P., Incompressible potential flow about axially symmetric bodies in ducts,** *J. aero. Sci.* 25, 1, 33-36, Jan. 1958.

For the case of an axially symmetric incompressible potential flow in an infinitely long duct of constant diameter the author derives the velocity potentials and stream functions for a point source, doublet, ring source, single doublet, disk source, disk doublet, and ring vortex. By separating the variables of the differential equations for the velocity potential, and superposition of solutions, results are obtained in series form with Bessel functions of the first kind of order zero and one.

R. Albrecht, Germany

3138. **Glauert, M. B., The flow past a rapidly rotating circular cylinder,** *Proc. roy. Soc. Lond.* (*A*) 242, 1228, 108-115, Oct. 1957.

If a circular cylinder in a uniform stream rotates very rapidly, there exists in the neighborhood of the cylinder a boundary layer which does not separate, but which circulates round the cylinder. Under the assumption that the flow in the boundary layer is laminar the velocity distribution in the boundary layer and the resultant circulation in the outside potential flow are calculated.

A. Betz, Germany

3139. **Staniukovich, K. P., Some forms of nonsteady plane and three-dimensional gas flow** (in Russian), *Proc. Acad. Sci. USSR. Appl. Phys. Section* 112, 1-6, 65-70, Jan.-Feb. 1957. (Consultants Bureau Translation *Doklady Akad. Nauk* SSSR 112, 1-6, 595-589. Translated copies obtainable from Consultants' Bureau, New York City.)

Theoretical relations are given for certain frictionless flows. One relation is a generalization of Busemann's relation for steady flow past ruled or conical surfaces. Another relation is a generalization of Prandtl-Meyer flow past any profile or corner.

R. C. Binder, USA

3140. Stevens, J. C., and Kolf, R. C., Vortex flow through horizontal orifices, *Proc. Amer. Soc. civ. Engrs.* **83,** SA 6, (*J. san. Engng. Div.*), Pap. 1461, 23 pp., Dec. 1957.

3141. Gabbay, E. J., Graphical estimation of flow through orifices, *Aircr. Engng.* **24,** 340, 175–178, June 1957.

3142. Martin, G. A., Solving flow control problems graphically, *Control Engng.* **4,** 12, 71–75, Dec. 1957.

Author treats the classical problem of matching fluid supply pressure-flow characteristics to load characteristics, employing specially ruled graph paper. A quadratic scale for the flow coordinate yields linear or nearly linear characteristics, permitting matching techniques for supply and load lines almost exactly equivalent to those long employed in electrical engineering practice. The bulk of the article is devoted to the results of treating conventional problems by this method.

H. M. Paynter, USA

Compressible Flow, Gas Dynamics

(See also Revs. 3026, 3149, 3150, 3166, 3185, 3191, 3192, 3249, 3255, 3293)

3143. Heims, S. P., Prandtl-Meyer expansion of chemically reacting gases in local chemical and thermodynamic equilibrium, *NACA TN* 4230, 11 pp. + 5 figs., Mar. 1958.

The relationship of flow-deflection angle to the state variables enthalpy and entropy is required for solution of many problems of air flow. When chemical reactions occur, as in high-temperature flow through a hypersonic nozzle, the relationship varies as a function of the level of the state variables and of the excitation and relaxation rates. The variation of Prandtl-Meyer expansion angle along an isentrope can be calculated for chemically reacting air in local thermodynamic and chemical equilibrium using, for example, the equations and Mollier diagram of Feldman, Saul, "Hypersonic gas dynamics chart for equilibrium Air." AVCO Research Laboratory, Jan. 1957. Therein, the Prandtl-Meyer angle is found by numerical integration of an equation containing terms of enthalpy and speed of sound, both obtainable from the Mollier diagram. In the present paper, the Mach angle is found first by numerical integration of an equation containing a slowly varying function of enthalpy and speed of sound. Next the Prandtl-Meyer angle is found as a function of Mach angle and local Mach number.

The main advantage of the present paper is that the quantity to be integrated varies slowly, thereby allowing larger steps in the numerical integration.

S. Kraus, USA

3144. Heims, S. P., Effect of oxygen recombination on one-dimensional flow at high Mach numbers, *NACA TN* 4144, 52 pp., Jan. 1958.

A theoretical analysis has been made of air flow in a stream tube in which oxygen dissociation and recombination occur. The theory developed permits a finite reaction rate which varies from point to point along the flow. An estimate of the rate of reaction is made and a numerical example is worked out for a stream tube with a shape that might be expected for air flowing behind the head-shock around a blunt body.

From author's summary by S. D. Nigam, India

3145. Koga, T., A method for solving problems of irrotational gas flow by means of high-speed digital computers, *J. appl. Mech.* **24,** 4, 497–500, Dec. 1957.

A numerical procedure is proposed for solution of certain problems in steady gas flow where subsonic, sonic, and supersonic regions appear simultaneously. The difficulties that occur in analytical methods for taking into account the differences of the type of the fundamental equation are avoided. Given a streamline and the state of the gas along that streamline, the coordinates of the neighboring streamline and the state of the gas along it can be computed. The procedure can be applied successively to cover a flow field.

From author's summary by H. M. Voss, USA

3146. Legras, J., Justification of an approximation of vibratory aerodynamic forces in three-dimensional subsonic flow (in French), *Rech. aéro.* no. 47, 21–26, Sept./Oct. 1955.

3147. Spreiter, J. R., Alksne, Alberta Y., and Hyett, B. Jeanne, Theoretical pressure distributions for several related nonlifting airfoils at high subsonic speeds, *NACA TN* 4148, 52 pp., Jan. 1958.

Theoretical pressure distributions on five related nonlifting airfoils, including thin symmetrical circular-arc airfoils, in two-dimensional flows with high subsonic free-stream velocity are presented. The airfoils have various locations for the point of maximum thickness, ranging from 30- to 70-percent chord and are of arbitrary, although small, thickness ratio. The Mach number range extends from well below the critical up to the lowest Mach number at which the shock wave is at the trailing edge of the airfoil. Results for the same family of airfoils and for Mach numbers equal to or near unity are presented in AMR **11** (1958), Rev. 537. The method of computation is described by authors in AMR **7** (1954), Rev. 3630, in which the differential equation of transonic-flow theory is recast into the form of a nonlinear integral equation and approximate solutions are obtained by an iteration procedure. A resumé of the theory is given in the interest of completeness and in order to provide some additional comments.

For subcritical Mach numbers the pressure distributions appear to be in good accordance with other theoretical results; for supercritical Mach numbers, where only comparison with experiment is possible, the theoretical results show substantial quantitative discrepancies; these discrepancies, however, are attributed to the influence of the wind-tunnel walls.

E. M. de Jager, Holland

3148. Kidder, R. E., Unsteady flow of gas through a semi-infinite porous medium, ASME Summer Conf., Berkeley, Calif., June 1957. Pap. 57-APM-13, 4 pp.

The full mathematical solution of this problem is difficult. It requires the solution of a nonlinear partial differential equation. An approximate method consists in solving an appropriate finite-difference equation by aid of modern digital computing equipment. As the initial and boundary conditions can be varied infinitely, the results of such methods are difficult to survey. Author has instead given an analytical solution of a specialized problem. The flow is one-dimensional, e.g. in direction of the x-axis. The pressure commences with a constant value for x positive. Then the pressure is kept at a lower constant value at $x = 0$ for all positive values of time t. The solution for positive x and t is expanded into a series, of which the first four terms are given. The series seems to be so rapidly convergent that further terms seem not to be needed for practical purposes.

O. H. Faxen, Sweden

3149. Morawetz, Cathleen S., On the non-existence of continuous transonic flows past profiles I, *Comm. pure appl. Math.* **9,** 1, 45–68, Feb. 1956.

Consider a steady continuous symmetric transonic flow with stream function ψ and potential ϕ past a profile $y = \pm Y(x)$. The perturbation problem is properly posed if there exists for general variation of the profile $\pm \delta Y(x)$, a flow stream function $\psi + \delta\psi$ and potential $\phi + \delta\phi$, having the same Mach number and flow direction at infinity and for which $\delta\psi, \delta\phi$ are small of the order δY. Author proves here that for convex symmetric bodies the variation of the

profile can be prescribed, at most, outside some finite arc containing the point of maximum velocity. The proof depends on neglecting higher-order terms in $\delta\psi$ and $\delta\phi$.

A. R. Mitchell, Scotland

3150. Morawetz, Cathleen S., On the non-existence of continuous transonic flows past profiles II, *Comm. pure appl. Math.* **10**, 1, 107–131, Feb. 1957.

A shock-free transonic flow exists past a symmetric convex profile. Consider another profile which differs only on an arc cut out by two intersecting characteristics of the original supersonic region. It is shown that, if the quadratic terms in the velocity and acceleration differences of the two flows are retained, there are no solutions of the nonlinear boundary-value problem satisfied by the velocity differences. This result is an extension of part I of the present paper [see preceding review].

A. R. Mitchell, Scotland

3151. Bevierre, P., Approximative calculation of the drag in transonic flow at angle of attack (in French), *Rech. aéro.* no. 47, 15–18, Sept./Oct. 1955.

3152. Griffith, W. C., and Kenny, Anne, On fully-dispersed shock waves in carbon dioxide, *J. Fluid Mech.* **3**, 3, 286–288, Dec. 1957.

It is pointed out that, for shock Mach numbers between 1 and 1.042, shocks in carbon dioxide are fully dispersed in the sense that the adjustments in the energy in all the degrees of freedom proceed slowly and in parallel and occur over a distance large compared with the mean free path. Theoretical velocity profiles for such shock waves are given and found to be in excellent agreement with interferometric shock-tube observations.

N. H. Johannesen, England

3153. Sakurai, A., A note on Mott-Smith's solution of the Boltzmann equation for a shock wave, *J. Fluid Mech.* **3**, 3, 255–260, Dec. 1957.

The Mott-Smith assumption that the molecular velocity distribution function inside a strong shock wave is merely a linear combination of the Maxwellian distributions for the states before and after the shock is shown in this paper to be a first approximation solution to the one-dimensional Boltzmann equation. A specific evaluation of the shock thickness results. The form of the error term suggests a solution for the distribution function in a power series in a certain function of Mach number. This further suggested form has been examined only to the point of noting serious convergence difficulties.

H. W. Emmons, USA

3154. Kawamura, R., and Kawada, H., A study on the attenuation of shock waves due to obstacles in the passage, *J. phys. Soc. Japan* **12**, 11, 1290–1297, Nov. 1957.

Using one-dimensional analysis, expression for drag of a body in a shock tube is derived as a function of attenuation rate and incident shock Mach number, where attenuation rate is defined as the ratio of difference between incident and transmitted shock Mach numbers to incident shock Mach number.

Some experiments are described measuring the drag of circular cylinders, flat plates, and semi-circular shells. In practice, the shock tube was divided into two passages, the obstacle being placed in one. Attenuation could then be measured directly from a single schlieren photograph showing transmitted wave in one passage and the undisturbed incident wave in the other.

Drag, and hence blockage, must be large to give sufficient attenuation for practical measurement, and the work is therefore of academic interest only.

F. G. Blight, Australia

3155. Badri Narayanan, M. A., Measurements of shock drag due to nose bluntness for a 40° cone-cylinder at M = 1.97, *J. aero. Soc. India* **9**, 3, 44–49, Aug. 1957.

Using a direct-reading drag balance, the nose drag of 40° cone cylinders with various degrees of bluntness at the nose has been measured at a Mach number of 1.97 at zero angle of attack.

From author's summary

3156. Heaslet, M. A., and Fuller, F. B., Drag minimization for wings in supersonic flow, with various constraints, *NACA TN* 4227, 30 pp., Feb. 1958.

Ward [British ARC Rep. 18, 711, FM 2459, Oct. 1956] has derived method which reduces problem of determining minimum inviscid fluid drag for thin aerodynamic shapes with given lift to a two-dimensional isoperimetric problem. Authors consider various other constraints such as given pitching moment, base area or volume [see also Heaslet, *NACA TN* 3289]. Interesting applications include elliptic planforms of given volume and a family of supersonic leading-edge wings with lift and center of pressure specified. For latter case additional information on loading distribution is derived. It is noted that minimum drags computed are not necessarily attainable by a real wing, but nevertheless provide a lower bound.

Reviewer cannot understand application of Kelvin's minimum energy theorem to develop approximate method for case of minimum drag with given lift, since theorem is applied in a context where not necessarily valid. Comparison of kinetic energies here is between two potential flows with same boundary conditions but with one having (unknown) velocity discontinuities on closed curve in the field. Success of approximate method must rest on other grounds.

H. C. Levey, Australia

3157. Love, E. S., and Lee, Louise P., Shape of initial portion of boundary of supersonic axisymmetric free jets at large jet pressure ratios, *NACA TN* 4195, 29 pp., Jan. 1958.

The rocket motor in many hypersonic vehicles is still operating at very high altitudes and there the free jet from the rocket nozzle spreads at a large angle due to extreme ratios of the pressure in the jet to that of the ambient air. Paper presents results of calculations for a jet Mach number of 2.5, semi-divergence angle of the nozzle of 15°, static pressure ratios of 60 to 42,000 and ratios of specific heats of 1.200, 1.400, and 1.667. The method of characteristics was used to find the jet boundaries. The initial inclination of free jet boundaries may approach and exceed 90° and consequently large regions of separated flow are to be expected on the vehicle and also possible interference effects.

H. Schuh, Sweden

3158. Heath, W. G., and Heath, B. O., Practical structural design problems of supersonic aircraft, *Aircr. Engng.* **24**, 341, 206–211, July 1957.

3159. Beastall, D., and Turner, J., The effect of a spike protruding in front of a bluff body at supersonic speeds, *Aero. Res. Counc. Rep. Mem.* 3007, 7 pp. + 13 tables + 26 figs., 1957.

3160. Frankl', F. I., Subsonic flow around a profile with a supersonic zone terminating in a direct density discontinuity (in Russian), *Prikl. Mat. Mekh.* **20**, 2, 196–202, Mar.–Apr. 1956.

Flows around a cylinder with supersonic zone terminating in a direct density discontinuity are discussed by the method of hodograph for the cases both with and without circulation. For simplicity sake it is assumed that the velocity at branch point differs from zero.

The existence and uniqueness of solution are not yet proved, and the probable existence of solution for such discontinuity is merely shown.

M. Kataoka, Japan

3161. Brown, D., An experimental investigation of the pressure recovery of a perforated-wall internal-compression intake at a free-stream Mach number of 2.5, *Univ. Toronto Inst. Aerophys. Rep.* 18, 15 pp. + 18 figs., May 1957.

Performance of a "reversed de Laval nozzle-type" intake with wall perforations is investigated experimentally at a free-stream Mach number 2.5. Both perforated area and exit area are varied, the maximum total pressure recovery measured being 81% as compared with 50% across the normal shock of a pitot intake. An estimate of the minimum loss of mass flow through the perforations gives a value of 23%, which effectively reduces its performance to that of a conventional pitot intake. Reviewer believes that if the positioning and size of the perforations had been determined from the starting criterion of Kantrowitz and Donaldson, the percentage spill would have been considerably reduced and a more favorable over-all performance obtained. G. C. Quigg, Australia

3162. Devienne, F. M., Experimental study of the stagnation temperature in a free molecular flow, *J. aero. Sci.* **24,** 6, 403–406, 412, June 1957.

Temperature rise of a small "insulated" flat plate oriented normal to its motion on a whirling arm apparatus was measured for molecular speed ratios *s* from 0.25 to 1.5. Data are given for air, argon, carbon dioxide, and freon 12, for blackened and polished copper plates.

Results obtained agree quantitatively with predictions of free molecular flow theory, assuming accommodation coefficient *a* varies with nature of gas, surface conditions of plate, and pressure —in agreement with known trends from experiments with plates at rest. Author claims results indicate that *a* also varies with speed ratio *s*.

Reviewer would have appreciated more details of apparatus, as basis for evaluating accuracy of test data, as well as more details of actual test data from which conclusions were drawn. It is noted that the correction for heat conduction from plate was measured at rest and was relatively large (actual temperature difference about 1.5 times measured difference). Also, possible error in using simplified Eq. (7) is not evaluated or discussed.

Reviewer notes that a more complete report by author was published (after submission of MS reviewed here) as Tech. Report under OSR/ARDC Contract no. AF61(514)-930 and is more satisfactory and lucid. J. S. Isenberg, USA

3163. Krzywoblocki, M. Z. v., and Shinosaki, G., On drag of some bodies in free molecule flow, *Acta Phys. Austr.* **10,** 1/2, 34–53, 1956.

3164. Krzywoblocki, M. Z. v., On some problems in free molecule-slip flow regimes, *Acta Phys. Austr.* **9,** 3/4, 216–257, 1955.

Wave Motion in Fluids

(See Revs. 2999, 3006, 3359, 3362, 3384)

Turbulence, Boundary Layer, etc.

(See also Revs. 3129, 3149, 3283, 3284, 3286, 3304)

3165. Demyanov, Yu. A., An application of A. A. Dorognitsyn's variables to the theory of the boundary layer (in Russian), *Prikl. Mat. Mekh.* **19,** 4, 507–508, 1955; *Ref. Zh. Mekh.* no. 12, 1956, Rev. 8345.

The equations of the steady motion of the boundary layer of a compressible gas, in the absence of a pressure gradient, are examined.

It is assumed that the coefficient of viscosity μ is a function of the enthalpy and the pressure

$$\mu = \frac{p}{\rho} f(H,p)$$

It is demonstrated that if the condition

$$\frac{f(c_p T,p)}{f(c_p T_\infty,p)} = \frac{f(T,p)}{f(T_\infty,p)}, \text{ where } c_p = \text{const}$$

is satisfied, the solutions of the equations by A. A. Dorodnitsyn's variables can be utilized, with a determined ratio of viscosity to temperature, for the solution of generalized equations.

V. S. Avduevskii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3166. Bertram, M. H., Boundary-layer displacement effects in air at Mach numbers of 6.8 and 9.6, *NACA TN* 4133, 45 pp. + 16 figs., Feb. 1958.

Experimental data in air are presented for pressure gradients induced by laminar boundary layer on a flat plate at a Mach number of 9.6. The measured pressure distribution agreed with a modified insulated-plate displacement theory, taking into account the heat transfer from boundary layer to plate and the temperature gradient along the surface.

Total drag of square and delta wings with maximum thickness ratios of 2.5% was tested at Mach 6.8 over a root-chord Reynolds number range of 0.7 to 5.5 million. The total drag was found to be as much as 30% greater than the sum of estimated pressure drag and classical skin friction. This drag increment is, in general, explainable on the basis of the effect of the boundary-layer-induced pressures on the skin friction.

H. P. Liepman, USA

3167. Hama, F. R., Note on the boundary-layer instability on a flat plate stopped suddenly, *J. aero. Sci.* **24,** 6, 471–472 (Readers' Forum), June 1957.

3168. Hurley, D. G., and Ruglen, N., A note on the cause of the nose stall of thin wings, *Aero. Res. Lab. Melbourne, Austral.* A 162, 10 pp. + 16 figs., May 1957.

Experiments have shown that the nose stall of a 6% thick wing is delayed by porous suction located downstream of the small laminar separation bubble. This result lends support to the suggestion of Wallis that the nose stall of thin wings results from turbulent separation occurring downstream of the small laminar separation bubble. It is considered that the present experiments definitely establish that this is the case at the highest Reynolds number covered (4.85 million). The results at lower Reynolds numbers are not considered to be conclusive.

From authors' summary

3169. Kline, S. J., Some new conceptions of the mechanism of stall in turbulent boundary layers, *J. aero. Sci.* **24,** 6, 470–471 (Readers' Forum), June 1957.

3170. Eckert, E. R. G., Donoughe, P. L., and Moore, Betty Jo, Velocity and friction characteristics of laminar viscous boundary-layer and channel flow over surfaces with ejection or suction, *NACA TN* 4102, 33 pp. + 5 tables + 7 figs., Dec. 1957.

Velocity field and friction coefficients of steady, fully developed laminar flow past porous walls are presented for flat duct (with one or both walls porous), round duct, and infinite wedge. Fluid properties and injection or suction flux density are assumed constant. The nonlinear differential equations of flow are solved in each case by iteration method using electronic com-

puter. Authors propose certain definitions of flow parameters to correlate results of different geometries. The final curves seem to lie close to one another. Reviewer finds the presentation in general faultless and the results useful.

L. S. Dzung, Switzerland

3171. Chambre, P. L., and Young, J. D., On the diffusion of a chemically reactive species in a laminar boundary layer flow, *Phys. of Fluids* **1**, 1, 48–54, Jan./Feb.

Authors discuss analytically the concentration pattern of a diffusing chemically reactive species in the boundary layer in an isothermal, laminar, incompressible, two-dimensional flow field. The reacting component is assumed to occur in very dilute form, so that the hydrodynamic field may be solved independently of the concentration field. For the Falkner-Skan [*Aero. Res. Com. Lond. Rep. Mem.* no. 1314, 1931] representation of flow part wedge-shaped bodies, the concentration may be expressed as an expansion according to Blasius [*Z. Math. Phys.* **56**, no. 1, 1908]. As an illustration, the development of a first-order reaction in the neighborhood of a flat plate is considered both for the case in which the reactant is generated in the fluid space, and for that in which it is destroyed.

M. A. Mayers, USA

3172. Fainzilber, A. M., Hydrodynamical similarity integrals of heterogeneous and homogeneous processes (in Russian), *Proc. Acad. Sci. USSR, Appl. Phys. Sections* **112**, 1–6, 51–55, Jan.-Feb. 1957. (Translation *Dokladi Akad. Nauk SSSR* **112**, 1–6, 607–610; Translated copies obtainable from Consultants' Bureau, Inc., New York City.)

Author states the differential equations of flow and concentration in a diffusing flow field and establishes a similarity relation between the vorticity and concentration. In addition, he obtains generalized similarity relationships for the cases of homogeneous reactions. For the case of flow along a plate, with reaction occurring at the surface, he obtains a solution in terms of a Blasius expansion [see also Chambre, P. D., and Young, J. D., "On the diffusion of a chemically reactive species in a laminar boundary-layer flow," *Phys. of Fluids* **1**, 1, 48–54, Jan./Feb., 1958].

M. A. Mayers, USA

3173. Richardson, N. R., and Horton, E. A., A thermal system for continuous monitoring of laminar and turbulent boundary-layer flows during routine flight, *NACA TN* 4108, 11 pp. + 14 figs., Sept. 1957.

A thermal system has been developed which could be used to determine whether the boundary layer on a wing in flight is turbulent or laminar. This system, when used in conjunction with continuous recording instruments such as the galvonometer in an NACA VGH recorder and a motordriven selector switch, would permit continuous monitoring of the boundary layer during routine flight with little or no attention from the crew. Detection is based on the difference in rate of heat transfer to a turbulent boundary layer as compared with that to a laminar boundary layer. The detectors, which consist of insulated resistance-thermometer gages cemented to the wing surface, combine the functions of heating and temperature measurement. Wind-tunnel tests indicate that a usable signal is obtained when the Reynolds number per foot is about 0.15×10^6 or greater. If the detectors can be matched well enough and the gage temperature increased, they may be feasible for use at somewhat lower Reynolds numbers.

From authors' summary

3174. Sibulkin, M., Boundary-layer measurements at supersonic nozzle throats, *J. aero. Sci.* **24**, 4, 249–252, 264, Apr. 1957.

Cleaver cantilever beam pitot probe and sliding static pressure tube extended from test section into throat of Jet Propulsion Laboratory 12-in. tunnel. Throat radii of curvature varied from 33 to 59 inches. Velocity profiles are found to fit same 1/7th power law for three different static pressure gradients in agreement with Clauser's prediction, since $(\theta/r)(\partial p/\partial x) = -0.26$ for all three cases. Paper is of interest for wind-tunnel nozzle-design corrections and heat transfer in rocket nozzles.

A. E. Bryson, Jr., USA

3175. Furuya, Y., and Suzuki, K., Experiments on initial state of flow separation in conical diffuser, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 341–344.

Experiments are described on the initial state of separation of air flow in a 20° conical diffuser, and experimental separation with theoretically calculated separation points of flow. Points of flow are compared.

From authors' summary

3176. Zyssina-Molozhen, L. M., The nature of the transition from laminar to turbulent flow in the boundary layer (in Russian), *Zh. tekh. fiz.* **25**, 7, 1280–1287, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7541.

An attempt is made to develop a semi-empirical method for evaluating the influence of the transitional region on the flow in the boundary layer. The impulse equation is employed in the form

$$df/dx = (U'/U)\,F(f) + (U''/U')\,f \qquad [1]$$

where $f = U'\delta^{**2}/\nu$ = form parameter, U velocity at the outer limit of the boundary layer, δ^{**} thickness of the loss of impulse, ν kinematic viscosity.

To determine the parameters of the boundary layer by Eq. [1] it is necessary to know the function $F(f)$ and the value of the relationship

$$G = G(R^{**}) \quad (G = 2/c_f,\ R^{**} = U\delta^{**}/\nu)$$

$$c_f = \text{coefficient of friction.}$$

Having determined the form of the functions $F(f)$ and $G(R^{**})$ for the transitional region in the same manner as is performed for the purely laminar and the purely turbulent layers, the parameters of the boundary layer with reference to the transitional region may be calculated.

Available experimental data and those obtained by the author indicate that, in the transitional region, the relationship $G = G(R^{**})$ is not monovalent and varies between one experiment and another. Hence it is suggested to use for the transitional region a particular mean relationship

$$G = \text{const}\,(R^{**})^{-\frac{1}{10}} \quad (200 < R^{**} < 4000)$$

In such case, author obtains the function $F(f)$ in the form of $F(f) = 0.9 - 6.55f$. If the coordinates of the beginning and the end of the transitional region are known, then, applying the relationships introduced, it is possible to calculate the boundary layer monotonously over the whole region of separation-free flow.

Author's comparison of experimental and analytical values, relating to the distribution of δ^{**} over the flow section and the profile losses in turbine and compressor blade cascades, referred to the angle of incidence of the flow, indicates that the suggested method is sufficiently accurate.

V. Ya. Likhushin

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3177. Napolitano, L. G., Critical study of the adequacy of integral methods in plane mixing problems, Polyt. Inst. Brooklyn Aero. Lab. Rep. 425, 60 pp. + 7 figs., Dec. 1957.

It is well known that, under certain restricted conditions, incompressible and compressible, turbulent and laminar plane isobaric homogeneous jet-mixing problem may be reducible to the solution of a unique laminar-incompressible-type system of

equations. In this paper the solution of such a system of equations by the Karman integral method is presented. By comparison with more accurate solution of series expansion it is found that the solution of profile of sixth-degree polynomial is very good. Hence the author's method is very useful for preliminary estimate of mixing problems of practical interest before more accurate and also very complicated calculations are made.

S. I. Pai, Germany

3178. Napolitano, L. G., Incompressible mixing of a shear flow with fluid at rest, Polyt. Inst. Brooklyn Aero. Lab. Rep. 318, 38 pp. + 6 figs. + vii, Nov. 1957.

The laminar and turbulent mixing of a nonuniform free stream of constant vorticity with fluid at rest is investigated. The solutions are given in the vorticity numbers first suggested by T. Y. Li [AMR **9** (1956), Rev. 1173]. It is found that the effects of a vorticity are negligible for laminar mixing and sizeable for turbulent mixing.

S. I. Pai, Germany

3179. Corrsin, S., Simple theory of an idealized turbulent mixer, *AIChE J.* **3**, 3, 329–330, Sept. 1957.

A simple statistical measure of nonuniformity in a fluid mixer is the mean-square fluctuation in concentration. An analysis for the mean-square concentration under the assumption of stationary isotropic turbulence leads to an expression for the power input needed by a mixer to maintain a steady state. Another result is a formula for the dependence of the power on the size of geometrically similar mixers at large Reynolds numbers when the mixing time is constant; this result is that the power varies as the size to the fifth power.

N. Tetervin, USA

3180. Betchov, R., On the fine structure of turbulent flows, *J. Fluid Mech.* **3**, 2, 205–216, Nov. 1957.

Author describes experimental work with a low-speed airstream of high turbulence produced by many small jets which merge in a closed tunnel. The eddy Reynolds number was $u'\lambda/\nu = 250$. Hot-wire measurements were made with specific arrangements for low electrical noise in order to analyze high-frequency waves. The results are corrected with regard to the finite length of the wire. Theory of this correction was proved experimentally.

The main results indicate a one-dimensional spectrum $F(k)$ of turbulence energy which falls with the $(-5/3)$-power of wave number k [1/cm] in the range $0.15 < k < 15$ and with the (-6)-power in the range $70 < k < 200$ (viscous range). For $k > 200$, electrical noise is important. The limit between the two ranges occurs about at $F(k)/\nu^2\ k = 5$. Comparison is also made with other experimental results.

An ultimate limit for spectral analysis is imposed by the molecular agitation of the gas. This limit can be estimated for a perfect gas and occurs in the present case at $k > 3000$.

N. Scholz, Germany

3181. Prausnitz, J. M., and Wilhelm, R. H., Turbulent concentration fluctuations in a packed bed, *Indust. Engng. Chem.* **49**, 6, 978–984, June 1957.

Quantitative measurements on scale and intensity of turbulence in packed beds explain theoretical and experimental relationships between concentration fluctuations and turbulence parameters.

From authors' summary

3182. Munk, M. M., Advances in understanding the mechanism of turbulent fluid motion Proc. Fifth Midwestern Conf. Fluid Mech., Univ. of Michigan, Apr. 1957, 160–169.

3183. MacMillan, F. A., Experiments on pitot-tubes in shear flow, *Aero. Res. Counc. Lond. Rep. Mem.* 3028, 12 pp., 1957.

When a pitot tube is used in a pipe or boundary layer, the shear and the presence of the wall may cause the pressure in the tube to differ from the true total pressure on the axis of the tube. To investigate these effects, measurements were made in a pipe of circular section, with turbulent flow, using pitot tubes of different external diameter D. Some supporting experiments were also made in a turbulent boundary layer on a flat plate with zero pressure gradient.

It was found that the effect of the shear alone could be conveniently expressed as a displacement δ_1 of the "effective center" of the tube towards the region of higher velocity. The value of δ_1/D was found to be 0.15, independent of Reynolds number and velocity gradient.

When the tube is near the wall, an additional correction must be applied. If this is expressed as a correction u to the measured velocity U, it is found that u/U is independent of Reynolds number within the accuracy of these experiments.

Alternatively, the effects of the wall and the shear together can be expressed as a total displacement δ of the effective center, but δ/D then depends on Reynolds number and also on the ratio of distance from the wall to tube diameter.

From author's summary

3184. Hool, J. N., Calibration of surface tubes for measurement of surface shear in fluids, *J. aero. Sci.* **24**, 6, 462–463 (Readers' Forum), June 1957.

Aerodynamics of Flight; Wind Forces

(See Revs. 2970, 2971, 3147, 3154, 3168, 3186, 3187, 3195, 3196, 3207, 3242, 3357, 3385)

Aeroelasticity (Flutter, Divergence, etc.)

(See also Revs. 2987, 3215, 3243)

3185. Malvestuto, F. S., Jr., and Goodwin, Julia M., Effect of angle of attack and thickness on aerodynamic coefficients of a rigid wing oscillating at very low frequencies in two-dimensional supersonic flow, *NACA TN* 4069, 65 pp., Jan. 1958.

Paper presents a collection of the pertinent equations and an extensive numerical evaluation of the effect of angle of attack, thickness, and Mach number upon two-dimensional supersonic wedge profiles plunging and rotating at low frequencies of oscillation. The calculations are based on inviscid linearized unsteady rotational-flow theory for the shock wave and its interaction with the Mach waves, while the pressure changes for a given flow deflection are based on the Busemann expansion up to the third order in flow angle, so that the entropy changes are approximated. Calculations are carried out only to angles of attack for which flow remains everywhere supersonic. Viscous flow separation has not been considered.

E. V. Laitone, USA

3186. Rosenblat, S., The aerodynamic forces on an aerofoil in non-uniform unsteady motion in a closed tunnel, *Phil. Trans. roy. Soc. Lond.* (*A*) **250**, 977, 247–278, Oct. 1957.

Two-dimensional unsteady motion of airfoil located midway between parallel walls, and moving through an inviscid, incompressible fluid, is investigated. A completely general upwash distribution is taken, and expressions are obtained for pressure on surface of airfoil, and lift and moment about mid-chord point. By a conformal transformation involving Jacobian elliptic functions, the physical plane is mapped into a rectangle, and the theory is based on a solution of the Laplace equation satisfying certain given conditions on this rectangle. Special cases are

considered in which the upwash is (a) a sudden upgust and (b) a harmonic oscillation. Detailed examination is made of a rigid-body airfoil performing translational and rotational harmonic oscillations. Aerodynamic forces are expressed in terms of dimensionless "air-load coefficients," which are then compared with corresponding coefficients for an airfoil in an infinitely deep stream. The air-load coefficients are obtained in a form which readily enables first-order corrections for wall interference to be evaluated. It is shown that the formulas derived are at variance with corresponding results obtained by other authors using different methods.

From author's summary by A. Balloffet, USA

3187. Molyneux, W. G., Flutter of wings with localised masses, *J. roy. aero. Soc.* **61,** 562, 667–678, Oct. 1957.

From a general consideration of the available data on the flutter of wings with localized masses, certain deductions are made as to the possible types of flutter that can occur. On the basis of these deductions it is shown that there is an optimum choice of modes for use in flutter calculations for wings with localized masses. These modes are obtained with artificial constraints imposed on the wing at the localized mass section fixing the wing at this section in translation and/or pitch. It is deduced that, for certain mass locations, types of flutter are obtained that are insensitive to increase of localized mass, beyond a certain value, with flutter speeds considerably greater than that of the fixed root bare wing. It is also deduced that, for the majority of aircraft configurations, the maximum flutter speeds for these types of flutter will be realized when the localized mass is in the region of two-thirds semispan from the root. A limited theoretical investigation is made for a rectangular unswept uniform wing with symmetric and antisymmetric body freedoms, to illustrate and confirm the conclusions derived from general considerations. At the same time the investigation shows that an ill-placed localized mass can reduce the wing flutter speed to a very low value.

From author's summary

3188. Richardson, A. S., Jr., Bending-torsion flutter sensitivity in incompressible and supersonic flow, Proc. Third Midwestern Conf. on Solid Mech., Univ. of Mich., Apr. 1957, 206–220.

Author suggests that "flutter sensitivity," defined as the slope at the flutter point of the velocity versus structural damping curve, may give misleading results as to the true character of the flutter. It should not be used as a measure of the violence of the flutter condition, as it really only gives an indication of the degree to which structural damping can affect flutter speed. As an alternate and more satisfactory sensitivity parameter it is suggested that the slope of the logarithmic decrement of the flutter mode versus airspeed should be used, as this gives a direct measure of the rate of growth of the amplitude of oscillation with increasing airspeed. Author considers theoretically bending-torsion flutter for incompressible flow and supersonic flow, and obtains results which fully support his views.

W. P. Jones, England

3189. Broadbent, E. G., Flutter prediction in practice, *AGARD Publications, Rep.* 44, 18 pp. + 3 tables + 19 figs., Apr. 1956.

Author gives a brief summary of the resources available for flutter prediction, both experimental and theoretical. Specific flutter investigations are described for four actual recent flutter incidents, in all of which good agreement is eventually obtained between calculations and full-scale experience. Conclusions for future guidance are drawn from all the examples, and a few points are given from a more general statistical survey of recent incidents.

From author's summary

3190. Hedgepeth, J. M., Flutter of rectangular simply supported panels at high supersonic speeds, *J. aero. Sci.* **24,** 8, 563–573, Aug. 1957.

Dynamic aeroelastic stability of unbuckled flat panels is analyzed using the linear plate differential equation, with arbitrary midplane stresses in both spanwise and chordwise directions. One side of the rectangular plate is exposed to nonviscous supersonic flow, airloads being linearly related to the chordwise slope by steady-state aerodynamic theory. Comparison with more exact theory justifies this aerodynamic approximation for Mach numbers exceeding roughly 2.

An exact solution based on two-dimensional airloads yields a critical dynamic-pressure-stiffness parameter, above which instability occurs. Its value depends only on one other parameter containing chordwise midplane stress and panel aspect ratio, and it is independent of spanwise midplane stress. When four terms are included in the spanwise modal function, a Galerkin approximation is found to agree well with the exact solution. This result is adduced to justify a Galerkin flutter analysis with three-dimensional airloads. After evaluating the generalized forces by means of simple numerical integrations, the flutter determinant is solved with four chordwise and two spanwise modal functions. The critical flutter parameter is again discovered to depend primarily, although not wholly, on the same single quantity occurring in the two-dimensional solution, with spanwise midplane stress having little influence.

In contrast to unrealistic results previously found for two-dimensional plates, the thicknesses of rectangular panels required to avoid flutter are reasonable and vary only gradually with Mach number in the supersonic range. Although asserting the need for more experimental data, especially on unbuckled panels, the author suggests his work "should provide useful design information for panels of moderately low aspect ratio."

H. Ashley, USA

3191. Fung, Y. C., On panel flutter, Inst. Aero. Sci. Nat. Summer Meet., Guggeneheim Aero. Lab., Cal. Inst. of Tech. Pasadena, Calif., (AFOSR-TR-57-49), June 1957, 82 pp.

Report is concerned with theoretical and experimental studies of the flutter of buckled panels in transonic and supersonic flow. It is found that the agreement between theory and experiment is improved by taking into account initial curvature of the panel, and that the static pressure differential across the panel is effective in preventing flutter only when it is sufficiently large. Considerable discussion is given to the application of Galerkin's method in the panel flutter problem.

H. N. Abramson, USA

3192. Fung, Y. C., Flutter of curved plates with edge compression in a supersonic flow, Proc. Third Midwestern Conf. on Solid Mech., Univ. of Mich., Apr. 1957, 221–245.

Author sets out to explain discrepancies between theory and experiments on large amplitude flutter of buckled plates in supersonic flow. The effect of pressure differential across the plate is investigated together with the influence of initial deflection of the plate. When the plate is not perfectly flat lateral deflection will occur under compression. Initial deviation from flatness, by reducing the compressive load, is beneficial to the prevention of flutter. The static pressure differential p across the plate has very little effect on the critical speed when p is small but becomes very effective in preventing flutter when p is sufficiently large.

From the theoretical evidence given author concludes that discrepancies were probably due to initial warping of the test specimens, but as the amount of warping was unknown his analysis could only indicate trends. It was found that the magnitude of the initial deviation from flatness of the plate required to bring theory and experiment into agreement was of the right order, but it is suggested that before accurate predictions of panel flutter can

be made more degrees of freedom will have to be taken into account. W. P. Jones, England

3193. Laidlaw, W. R., and Beals, V. L., Jr., The application of rocket sled techniques to flutter testing, *Aero. Engng. Rev.* **16**, 8, 58-62, Aug. 1957.

It is pointed out that sled testing performs a dual function for the flutter engineer—a check on the theoretical calculations and a final measure of the margins of safety of the new design.

From authors' summary

3194. Zvara, J., A theoretical and experimental investigation of the stability of a hovering helicopter rotor blade, Proc. Third Midwestern Conf. on Solid Mech., Univ. of Mich., Apr. 1957, 113-134.

Author correlates theoretical and experimental work on flutter and divergence of a rotor blade to find the blade characteristics which enable unstable motions to occur.

Three degrees of freedom were taken in the theoretical work (pitch and two independent vertical deflections of the rotor blade). Torsional flexibility was assumed to arise mainly from the control system. Aerodynamic derivatives were based on (1) quasi-static theory, (2) Theodorsen's function $C(k)$ [*NACA TR* 496] and (3) Loewy's function $C'(K^k, v, b)$ [AMR **10** (1957), Rev. 2224]. Structural damping was also allowed for.

Quasi-static derivatives generally give conservative results. Much better agreement with experiment is obtained when Theodorsen's functions are used. For the model tested, Loewy's theory did not give very different results from Theodorsen's.

Cantilevered, articulated and teetering rotors were used with a set of flexible blades and with a set of relatively rigid blades. Effects of varying (1) c.g. position, (2) feathering axis, and (3) blade flapping angle were investigated.

Three different types of instability were encountered: (1) a pitch divergence, (2) a mild flutter and a pitch divergence, and (3) pure flutter. A two-degrees-of-freedom analysis (flapping and pitching modes) is sufficient to determine the stability boundaries.

There was excellent agreement between theory and experiment. It is shown that unstable motions can occur with the c.g. well forward of the quarter chord for a teetering rotor with blades set at a positive coning angle and with the feathering axis out of the plane of the blade. A. W. Babister, Scotland

3195. Cole, H. A., Jr., and Holleman, E. C., Measured and predicted dynamic response characteristics of a flexible airplane to elevator control over a frequency range including three structural modes, *NACA TN* 4147, 37 pp. + 2 tables + 21 figs., Feb. 1958.

The longitudinal frequency response of a large flexible swept-wing airplane was determined from its response to elevator pulses. This response is given over a Mach number range of 0.5 to 0.76 and an altitude range of 15,000 to 35,000 ft.

The results indicate that the upper limit of the agreement between the calculated frequency response and the measured response depends upon the complexity of the assumed structural model. For example, the dynamic analysis with a single structural degree of freedom (wing first bending) and with quasi-steady aerodynamic theory "...adequately predicts the response through the frequency of the wing first-bending mode." However, the more complex elastic motion requires more accurate formulation to give a good prediction of the frequency response. In estimating the mode shapes at the higher frequencies, it was found that "...Node lines measured in ground vibration tests with the particular airplane support used did not agree with the lines of small response measured in flight."

Reviewer believes that the importance of these results lies in showing the need for accurate influence coefficients for the fuselage bending and other higher modes, if an accurate frequency response is desired over a wide frequency range. It should be noted that this type analysis has a definite upper limit on frequency. This limit is fixed by the use of quasi-steady aerodynamics and the neglect of shear and rotary inertia in the structural equations. E. E. Covert, USA

3196. Van de Vooren, A. I., and Schatz, O., Comparative calculations of divergence speed for wings of not too large aspect ratio, *Nat. LuchtLab. Amsterdam Rap.* R. 197, 10 pp. + 5 tables + 5 figs., Jan. 1957.

Report shows that neither the use of lifting-line theory nor the use of strip theory will predict, for a low-aspect-ratio rectangular wing, an accurate value of divergence speed. The divergence speed was calculated as an eigenvalue of a homogeneous integral equation described in a reference. This method is independent of the loading theory, which here included strip, line, and surface. Calculations were for an effective aspect ratio equal to 2.86 (wing aspect ratio of 4 at Mach number of 0.7). Surface theory was based on two chordwise pivotal points. The line and strip methods assume center of pressure at 1/4 chord. With elastic axis at positions 5 and 20% aft of 1/4 chord the divergence speed calculated by line theory is, respectively, 41 and 11% higher than that obtained by surface theory. Also, torsional deformation is underestimated by line theory.

Physically, the principal differences are due to the forward position of center of pressure characteristic of the low-aspect-ratio rectangular wing. J. DeYoung, USA

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 2947, 2987, 3161, 3194, 3247, 3325, 3326, 3368)

3197. Borodkin, V. C., Laboratory investigations of the kinematic raising of deep waters by means of air bubbles (in Russian), *Trudi Leningr. in-ta inzh. vod. transp.* no. 22, 152-165, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 720.

A description is given of experiments carried out to investigate the range of velocities created in still and running water as a result of the lifting of air bubbles from the bottom of a water basin to its surface. The experiments were carried out in the tanks of the hydrotechnical laboratory LIIVT and imitated the appliances used for the raising of water from the deep layers of a water basin by means of compressed air, delivered through perforated tubes laid on the bottom of the water basin. The experiments were carried out with several combinations of water-depth, air expenditure, and flow velocity in the tank. The range of velocities was studied with the help of photography and measurements of the components of the velocity; a study was specially made of the surface velocity, for which, in the absence of flow in the tank, an empirical formula is allotted; a formula by I. M. Konovalov [ibid, 1951, no. 18] for the assumption of air and for the velocity of the ascending flow was checked and experimental corrections were made in the coefficients of the formulas named.

V. A. Arkhangel'skii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3198. Blatchley, C. G., Control of steam-jet vacuum pumps, ASME Fall Meet., Hartford, Conn., Sept. 1957. Pap. 57-F-15, 7 pp.

3199. Dornaus, W. L., Flow characteristics of a multiple-cell pump basin, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-59, 8 pp.

3200. Radin, K. G., Some results of the measurement of flow in a stage of an axial compressor (in Russian), *Trudi Leningr. politekhn. in-ta* no. 177, 123–129, 1955; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6551.

Results are given of the measurement of the flow parameters in the input guide apparatus of an axial compressor designed in the TsKTI, which were obtained during the tests of the experimental stage. The blade apparatus is calculated according to the law of constant circulation of the velocity in all sections with a reaction stage of 100%.

The relative pitch of the cascade of the guide apparatus is $t = 1.62$ at $r = 1.0$ and $t = 0.858$ at $r = 0.53$, the relative length of the blade $l/b = 1.57$. The Reynolds number R and the Mach number at which the tests were performed are calculated from the mean velocity of the flow behind the guide apparatus and the length of the chord of the blade, and were, respectively, $R = 0.12 \times 10^6$ and $M = 0.18$.

The turning of the flow in the inlet nozzle was the cause of the uneven distribution of the pressures and axial velocities along the radius of the profluent part of the stage.

Data are given on the measurement of the outlet angle of the flow from the guiding apparatus for three different angles of setting of the blades; an empirical formula is suggested for the relationship of this angle to the angle of setting of the blade.

In these tests the flow in the working wheel was substantially uneven in a radial direction.

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3201. Valensi, J., Experimental investigation of the rotating stall in a single-stage axial compressor, *J. aero. Sci.* **25,** 1, 1–10, Jan. 1958.

Paper describes investigation of rotating stall in compressor by means of stagnation pressure measurement and smoke survey to complement observations by hot-wire anemometer and static pressure measurement. Investigation was carried out on a compressor consisting of 30 inlet guide vanes with solid body prerotation followed by a row of 31 rotor blades designed for constant work along span and a row of stator blades re-establishing conditions at rotor inlet. Measurements were made with stagnation and static pressure probes using quick response gages of the variable air-gap inductance type. Photographs of smoke filaments have been taken by an ordinary camera for strobosopic observation and a rotating drum for images in rapid succession. Three types of stall were observed on throttling from peak pressure point. First type initiates on rotor blades and affects only outer part of blades. Stalled region extends up stream until second type of stall occurs due to separation over guide vanes. Third type starts on rotor blades as a result of total span separation from their leading edges. Paper concludes that both techniques yield results in good agreement, and smoke surveys appear of aid in explanation of rotating stall mechanism.

A. F. W. Langford, Australia

3202. Goldstein, S., and Jaumotte, A. L., Rotating stall of the single-stage axial-flow compressor(similarity laws) (in French), *ZAMP* **8,** 3, 235–251, Mar. 1957.

Paper deals with experiments on a single rotor concerning the rotating stall characterized by the flow separation that occurs simultaneously at the roots and the tips of the blades. Authors show that (1) a certain relation exists between pressure coefficient and flow coefficient in the whole range of working condition, and (2) the ratio of the velocity of the rotating stall to that of the rotor is almost independent of the working condition. Several methods used for measuring the velocity of the rotating stall are described. In particular, authors show that this can be determined with good accuracy from the analysis of sound and vibration caused by the rotating stall.

F. Tamaki, Japan

3203. Gabriel, D., Wallner, L., Lubick, R., and Vasu, G., Some effects of inlet pressure and temperature transients on turbojet engines, *Aero. Engng. Rev.* **16,** 9, 54–59, Sept. 1957.

Compressor stall as a limit of engine performance and the methods of analysis for the prediction of the stall limits are discussed.

From authors' summary

3204. Godwin, W. R., Effect of sweep on performance of compressor blade sections as indicated by swept-blade rotor, unswept-blade rotor, and cascade tests, *NACA TN* 4062, 11 pp. + 14 figs., July 1957.

An investigation has been made to determine the induced effect of sweep on an axial-flow compressor blade. Velocities of entering and exiting flow and blade-section pressure distributions were measured at three radial stations on a 30° swept-blade rotor of 0.69 hub-tip ratio having the same blade geometric characteristics as an NACA 65-series unswept-blade rotor for which similar quantities were measured and the results presented in *NACA TN* 3806. In these tests, the blade tip speed was 183 fps and the inlet Mach number relative to the rotor ranged from 0.25 to 0.45. The blade-section pressure distributions were obtained by the use of a mercury-seal pressure-transfer device. The data obtained were also compared with similar data for the same blade sections obtained from a two-dimensional porous-wall cascade tunnel.

The comparisons of blade-section pressure distributions indicated that, in order to obtain the same effective angles of attack on the swept-blade rotor as on the unswept-blade rotor, the swept blade would require an additional twist of 3.8° for the entire radial span. Two-dimensional cascade data adequately predicted the turning angle through the swept-blade rotor if the change in axial velocity provided by the trailing portion of the blade was taken into account.

From author's summary

3205. Carter, A. D. S., Andrews, S. J., and Fielder, E. A., The design and testing of an axial compressor having a mean stage temperature rise of 30 deg C, *Aero. Res. Counc. Lond. Rep. Mem.* 2985, 14 pp., 1957.

This report describes a compressor which was designed to give a mean stage temperature rise of 30C. It has six stages so that the over-all pressure ratio at the design point is 4.5:1. Full details of the factors which led to the form adopted and of the design itself are given.

The test results fully substantiate the design assumptions. In particular, using standard design data, it is possible to achieve temperature rises of about 30C without sacrificing unduly any desirable performance features. Such temperature rises are considerably above those being used at the time this work was carried out, and are in fact substantially above the mean value used in present-day designs.

Details of the stage characteristics and the matching of the compressor are given in the report, together with some other points of special interest.

From authors' summary

3206. Turner, R. C., and Hughes, Hazel P., Tests on rough surfaced compressor blading, *Aero. Res. Counc. curr. Pap.* 306, 18 pp. + 19 figs., 1956.

Six stages of medium stagger free vortex blading, with rough surface finish, were tested in the N.G.T.E. 106 compressor. Over-all characteristics were determined at various speeds and compared with those of similar blading with the conventional smooth finish.

It was established that appreciable losses in temperature rise coefficient and efficiency were exhibited, and hoped-for gains in performance at low Reynolds numbers were not realized. There was no change in the general shape of the characteristics at any speed.

The condition of the boundary layer on a blade of the fifth stage stator row was investigated by means of pitot traverse and sensitive film techniques. No appreciable difference was found in this respect between the two sets of blades.

From authors' summary

3207. Paul, C. H., Operational experience with auxiliary gas turbines for aircraft, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-121, 7 pp.

3208. Kirillov, I. I., The variation in the initial and final steam flow characteristics in the turbine (in Russian), *Trudi Bezbibsk. in-ta transp. masbinostr.* no. 15, 61-70, 1955; *Ref. Zb. Mekb.* no. 12, 1956, Rev. 8188.

Author investigates the flow of gas through a system of successive nozzles and arrives at an approximate formula for determining the flow volume in the presence of pressure variations at entry and exit. The assumptions are defined under which this formula is applicable to determine the change in flow volume in different working conditions. Author mentions the services of A. Stodola in the investigation of turbine working conditions, and suggests that the formula discussed, erroneously attributed to Flugel, should be called the Stodola formula. N. A. Kolokol'tsov

Courtesy Referativnyi Zburnal, USSR
Translation, courtesy Ministry of Supply, England

3209. Petchuk, V. I., The influence of the shape of the leading edge of a profile on the character of the flow in the guide ducts of a turbine cascade (in Russian), Collected trans. inst. thermal energy, Akad. Nauk USSR, no. 12, 78-90, 1955; *Ref. Zb. Mekb.* no. 12, 1956, Rev. 8176.

An experimental investigation has been made, under static conditions, of three rectilinear, turbine cascades of the action type, composed of profiles differing by the radius of the rounding of the leading edge: $2R/m = 0.091, 0.259, 0.546$; where R is the radius of the rounded leading edge, and m the maximum thickness of the profile.

Drawings are presented of the profiles and the geometrical parameters of the cascades, and a brief description of the CKTI [*Trans. Centr. Sci. Res. Inst.* on "Boiler of turbine construction," 1950, no. 18].

Curves are given for the distribution of the nondimensional velocities over the profiles at angles of attack of $+7.5°$, $0°$, $-5°$, $-9°$, $-20°$, measured from the tangent to the centerline of the profile at the leading edge. The velocities are calculated from the pressure values measured in the plane of the median section through apertures in the blade wall.

Author recommends selection of the radius of rounding of the leading edge on the condition of the absence of diffusor sections near the leading edge.

The article omits the generally accepted evaluation of the losses in the experimental cascades, and fails to indicate the characteristic velocity selected, as well as the Mach values, at which the experiments were made.

The appearance of diffusor sections at the entry for profiles with a sharp leading edge is explained by the "presence of Joukousky vortices"; while for profiles with a large radius of rounding of the leading edge, by the braking of the fluid flow. According to the author, the smoothing of the velocities in the trailing section of the blade duct is conditioned by viscosity influences.

In pointing out that there is at the present time no theoretical method in existence for determining the shape of the leading edge of a cascade, author has omitted to consider the known analytical methods for the construction of blade cascades with a favorable distribution of the velocity over the profile [e.g. M. E. Deutsch: "Engineering gas dynamics," Gosenergoizdat, 1953, 333-334].

V. L. Epshtein

Courtesy Referativnyi Zburnal, USSR
Translation, courtesy Ministry of Supply, England

3210. Hill, R. C., Gas-turbine maintenance in severe service, *Mech. Engng., N. Y.* **79,** 7, 639-642, July 1957.

3211. Nagao, F., and Hirako, Y., Studies on the method of evaluation for the performance of the turbocharged diesel engine, Proc. Sixth Japan Nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 401-405.

3212. Cross, R. C., Experiments with internal-combustion engines, Instn. mech. Engrs. Auto. Div., Prepr., 18 pp., 1957.

3213. Williams, T., and Pullman, W. A., A method of valve timing design for two-stroke cycle engines, *J. roy. aero. Soc. Lond.* **61,** 559, 492-493, July 1957.

A method is described for determining the inlet and exhaust valve area requirements of a two-stroke cycle engine. It is shown that the valve timings are interdependent and that the final choice is a compromise with a number of other factors.

From authors' summary

3214. Schmidt, R., The influence of ambient pressure and temperature variations upon the static thrust of several kinds of aero-engines (in Spanish), *Comun. Inform. Escuela super. Aerotecn. Cordoba* no. 1-5, 19 pp., Mar. 1956.

The present report deals with some formulas derived for the calculation of the influence of ambient pressure and temperature variations upon the static thrust of several kinds of aero-engines. Piston-engines with and without afterburner and turboprops are considered. The formulas have been numerically evaluated. The introduction of the results into the conversion formulas derived by Göthert-Ribnitz permits an easy calculation of the effect of pressure or temperature variations upon the length of the take-off run of modern airplanes. From author's summary

3215. Lane, F., and Friedman, M., Theoretical investigation of subsonic oscillatory blade-row aerodynamics, *NACA TN* 4136, 50 pp. + 4 tables + 10 figs., Feb. 1958.

A method is presented for calculating the aerodynamic lifts and moments experienced by a cascade or two-dimensional approximation to a compressor or turbine blade row in subsonic flow under harmonic oscillation. Arbitrary stagger and interblade phase-lag angles are permitted. The most significant features of the method stem from the utilization of Fourier transforms of blade pressure-jump functions.

From authors' summary by H. P. Liepman, USA

3216. Korvin-Kroukovsky, B. V., and Jacobs, Winnifred R., Circumferentially nonuniform ship propeller inflow, *Inter. Sbipbldg. Progr.* **4,** 38, 520-530, Oct. 1957.

The effect of the circumferential nonuniformity of the thrust distribution on the propeller inflow is quantitatively investigated in the present paper; expressions are derived for the velocity potential and for various components of the inflow velocities resulting from this nonuniformity. The calculations of the propeller inflow velocity for the case of a circumferentially uniform thrust distribution were presented in a previous paper. The objective of that work was to provide material for the calculation of the wake fraction and thrust deduction of a ship propeller. It was pointed out at the same time that the thrust deduction probably would be strongly affected by the circumferential nonuniformity of the thrust distribu-

tion, and so the present task of calculating the velocities induced by this nonuniformity was initiated.

From authors' summary by T. P. Torda, USA

3217. Banister, T. H., The design study of a spring tab rotor system, *J. Helicop. Assn.* **10,** 2, 103-117, Oct. 1956.

Analysis is performed on several aspects of the design and behavior of a rotor whose blades are equipped with spring tabs along the trailing edge.

Comparison is made between the thrust distribution given by this system and classical ones. For the purpose, the theory of the blade element as applied by Glauert is used.

Favorable distributions are obtained from this comparison for the rotor with spring tabs, which gives a smaller induced power as well as a reduction of the required control. Furthermore it also results in a relief of the flexion vibrations which appear at high advancing velocities.

Author suggests an assembly on rubber in order to extend the life of the spring tabs up to a reasonable amount of hours (100 to 200 hrs). The system is suggested to be particularly suitable for light helicopters in which the blades could have a stiff connection without flapping.

No experimental results are given. It is reviewer's opinion that the adoption of the system depends mainly on the disposition which allows obtaining spring-tabs sufficiently resistant to fatigue and at the same time of fairly uncomplicated assembly.

G. Millan, Spain

3218. Jamison, R. R., Ram-jets, *J. roy. aero. Soc.* **61,** 558, 407-421, June 1957.

3219. Schmidt, R., On the influence of air conditions on the thrust of recent propulsion systems (in German), *Z. Flugwiss.* **5,** 5, 139-149, May 1957.

Paper gives results of method for estimation of influence of air pressure and temperature variations on thrust of modern engines—ramjet, turbojet with and without afterburning, turboprop. Brief discussion is given of Otto cycle.

Results found are complicated, but are usefully reduced to simple charts giving effect of variation of single parameters. From these charts relative sensitivity of various engines to variations of environmental parameters can be quickly deduced. Reduction of measured values to standard atmospheric conditions can easily be accomplished by these charts, to a useful high level of precision.

B. W. Augenstein, USA

Flow and Flight Test Techniques

(See also Revs. 3030, 3163, 3183, 3193, 3199, 3306)

3220. Moore, W. L., and Morgan, C. W., The hydraulic jump at an abrupt drop, *Proc. Amer. Soc. civ. Engrs.* **83,** HY 6 (*J. Hydr. Div.*), Pap. 1449, 22 pp., Dec. 1957.

A hydraulic jump may be useful in dissipating the kinetic energy of the flowing water in order to prevent erosion of the channel downstream from a hydraulic structure. Present paper concerns characteristics of the jump at an abrupt drop in the channel bottom especially when the drop is located within the length of the jump. Pertinent dimemsionless parameters are relative height of jump, relative height of drop, relative piezometric head on drop, and Froude number of the entering flow. Details of relationships among these parameters, obtained both theoretically and experimentally, are shown and discussed. Velocity near the channel bottom is also considered. Results indicate, among other things, that an abrupt drop in the bottom of a rectangular channel is effective in stabilizing the hydraulic jump over a broad and continuous range of values of the relative downstream depth. Application of the results to the analysis of a stilling basin is shown.

M. Morduchow, USA

3221. Zakaznov, N. P., New method of measuring an air flow (in Russian), *Meteorolog. i gidrologiya* no. 6, 53-54, 1955; *Ref. Zb. Mekb.* no. 1, 1957, Rev. 809.

A method is proposed for measuring the speed and direction of the velocity of an air stream by means of a single-bladed air-vane, connected to a rotatable synchronized motor; then a change in the external mechanical loading should lead to a change in the electric power, which when measured (for instance, by measurement of the current in the excitation winding at constant voltage) should make it possible, as stated by the author, to determine the average value for the speed of the disturbed flow. It is assumed also that the inertia of measurements with the apparatus can be very small, that is to say that the apparatus can be adapted for recording instantaneous values and directions of the airflow.

S. G. Popov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3222. Petrov, A. I., Conditions for complete physical similarity of flow of an incompressible liquid in rotameters and methods of graduating rotameters (in Russian), *Izmerit. tekhnika* no. 4, 3-6, 1955; *Ref. Zb. Mekb.* no. 1, 1957, Rev. 801.

Utilizing dimensional theory, nondimensional parameters are deduced connecting the output of liquid measured by the rotameter with the lift in height of the float. The results of the rotameter calibrations are given as a graphical relation between the indicated parameters. In making these deductions an error in method appears to be the introduction of relation γ/g in place of density ρ, as acceleration g does not enter into the number of determining parameters (in so far as an idea of the effective weight being introduced is concerned), in the similarity parameters (7), the value g is discarded as unfounded, and consequently the second of the formulas (7) gives the relation between the magnitudes being measured. These defects are not reproduced in the calibration curves, which have been constructed on a properly selected set of coefficients.

B. V. Aronov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3223. Broido, N. F., Diaphragm syncho-differential manometers (in Russian), *Gidroliznaya i lesokhim. prom-st.* no. 5, 27-29, 1955; *Ref. Zb. Mekb.* no. 10, 1956, Rev. 6799.

Paper describes mechanical synchro-differential manometers of types "MDM" and "DM" having metallic diaphragms (in series with "VEP" secondary instruments), manufactured instead of floating ones with a mercury filling. Two types of manometer are manufactured: those with scales and integrators, and non-scale generators performing several functions. Synchro-differential manometers of both types are made for various measuring ranges; for pressure drops up to 1000-mm water column for measurement of the pressure or pull up to 6300-mm water column, and for the measurement of level up to 630 mm of the column of the liquid to be measured.

D. L. Kalashnikov

Courtesy Referativnyi Zhurnal, USSR

Translation courtesy Ministry of Supply, England

3224. Pezevezentsev, I. G., A water-platinum manometer (in Russian), *Trudi Uralsk. n.-i. khim. in-ta* no. 2, 274-279, 1954; *Ref. Zb. Mekb.* no. 11, 1956, Rev. 7648.

An arrangement is described for a water-platinum manometer for remote recording of pressure measurements, consisting of a glass U-tube pressure gage with platinum wires stretched along the centerline of each leg of the tube. The manometer is half-filled

with water and immersed in a water-bath thermostat. A diagram for connecting the instrument in an electrical circuit is presented. A theoretical analysis of the arrangement is made, and the results of an experimental investigation are presented. It is shown that appropriate matching of the electrical resistances will enable a high accuracy of measurement to be obtained. Diagrammatic representations are given of six different arrangements for such a manometer, intended for measuring very small, as well as relatively large, pressure gradients, of the order of several thousand millimeters of water. N. A. Zaks

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3225. **Kastrov, V. G., The inertia corrections for a vertical recording anemometer** (in Russian), *Trudi Centr. Aerolog. Observ.* no. 14, 58–66, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7647.

The work of a vane anemometer on a horizontal axis, intended for measuring the vertical component of a wind velocity, is examined. From analysis of the motion of such a vane system, an equation is derived and a nomogram plotted, enabling determination of correction to be applied to the anemometer readings for known parameters of its inertia characteristics: pitch H, speed of arrest W^*, and synchronization path L. A method is investigated of determining the aforesaid characteristic parameters of anemometer by calibration data. The practical example included shows that in certain cases the inertia correction may represent as much as 25% of the indicated (measured) value. Yu. G. Zakharov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3226. **Shafer, M. R., and Ruegg, F. W., Liquid flowmeter, calibration techniques,** ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-70, 7 pp.

Calibration techniques for liquid flowmeters are discussed with emphasis on problems which are known to influence the accuracy of calibration procedures. Also, reference methods which have been used to evaluate the comparative accuracy of different calibrators are described. The results of comparative accuracy tests on four calibrators of different designs are presented and it is shown that the agreement between these is within ± 0.15% in the test range of 10,000 to 100,000 lb per hr. The many precautions necessary to approach this precision from the traditionally accepted "plus and minus one per cent" are given in detail.

From authors' summary

3227. **Gilzin, K. A., Calculation and design of rotameters for measuring of the discharge of liquids** (in Russian), *Izmerit. tekhnika* no. 4, 6–12, 1955; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6789.

3228. **Ducoffe,, A. L., Bennett, J. R., and Ray, C. G., Subcritical and critical flow through straight-through, elbow, and tee A-N fittings and sharp-edged orifices at elevated temperatures,** ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-60, 8 pp.

Paper presents the results of an investigation of the flow through straight-through, elbow, and tee A-N standard fittings at negligible approach velocity with approach temperatures up to 1100 F and head pressures up to 60 psia. The element pressure ratio, i.e., the ratio of downstream to upstream static pressure across the test element, was varied between 1.0 and approximately 0.25. Empirical equations for the subcritical and critical flow regimes are derived for the rate of weight flow as a function of element pressure ratio, flow area, and approach temperature and pressure. Empirical equations for a given geometry are derived for a flow factor which is shown to be a function of pressure ratio only in both the subcritical and critical regions. In addition, previous work at room temperature on the flow through sharp-edged orifices in the subcritical and critical regimes has been extended to include a variation of approach temperature up to 1100 F.

From authors' summary

3229. **Sprenkle, R. E., and Courtright, N. S., Straightening vanes for flow measurement,** ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-76, 4 pp.

3230. **Pedan, M. S., Development and investigation of an absolute method of measuring the velocity of an air flow and determination of the coefficients of model high-speed pipes** (in Russian), Thesis, Vses. n.-i. in-ta metrol., Leningrad, 1955; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6813.

3231. **Sharavskii, P. V., and Oborin, L. A., Use of thermoresistances for the measurement of low water speeds in the settling tanks of waterworks** (in Russian), 13-ya. nauch. konferentsiya Leningr. inzh.-stroit. in-ta, Leningrad, 1955, 246–247; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6787.

3232. **Enkenhus, K. R., Pressure probes at very low density,** *Univ. Toronto Inst. Aerophys.* Rep. 43, 66 pp. + 55 figs. + 25 tables + 11 plates, Jan. 1957.

3233. **Kazakevich, V. V., Use of throttle instruments for measuring the discharge of liquids at low Reynolds numbers** (in Russian), *Izv. Akad. Nauk SSSR, Otd. tekhn. nauk* no. 12, 125–128, 1955; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6788.

3234. **Brandy, E. J. O., How you can measure air flow,** *Prod. Engng.* **28**, 6, 145–150, June 1957.

3235. **Ibrahim, A. A. K., and Kabiel, A. M. I., Experimental and theoretical investigations on the oscillating cylinder viscometer for non-elastic liquids,** *J. phys. Soc. Japan* **12**, 11, 1304–1311, Nov. 1957.

An exact theory is developed for Newtonian liquids in a viscometer consisting of a cylindrical bob suspended by a torsion wire concentrically in a cylindrical cup. The cup is oscillated at a frequency n through a small angle at a constant angular velocity, and the amplitude of the oscillations, ψ, of the inner cylinder is observed.

The solution is obtained graphically, at the intersection of a plot of experimental values of ψ against n, with a simple theoretical expression between these quantities given in the paper.

With inner and outer diameters of 0.9 and 1.26 cm, good accuracy was obtained with $n > 25$ cycles/min and viscosity > 5 poises; lower values did not yield perfect simple harmonic motion. The inertia of the bob had to be increased to avoid resonance. Depth of immersion exceeded 7.8 cm, and no end effect was observed. C. F. Bonilla, USA

3236. **Kestin, J., and Wang, H.-E., Corrections for the oscillating-disk viscometer,** ASME Ann. Meet., New York, N. Y., Nov. 1956. Pap. 56-A-34, 10 pp.

Paper reviews existing theories of the oscillating-disk viscometer and demonstrates their inadequacy. Using the results obtained previously by Kestin and Persen together with an empirical assumption that the edge-correction factor is proportional to the ideal viscous torque pieced together from the infinite-disk and infinite-cylinder solutions, authors are able to develop working formulas which, in addition to the edge effect, include the effect of wire damping and unequal separation. The effect of a stem is discussed separately and shown to be negligible. Some remarks are made about the decrement-period relationship. The assumptions are compared with experimental results which demonstrate that for a given suspension system the edge-correction factor C depends on

the dimensionless ratio $X_0 = \delta/R$ (δ is the average boundary-layer thickness and R is the external radius of the disk) in a unique way. This shows that the use of the authors' equations together with a suitable calibration procedure should lead to reliable values of viscosity.

From authors' summary by H. Ashley, USA

3237. Zolotykh., E. V., Investigation of the relationship of the viscosity of liquids to pressure up to 5000 kg/cm² (in Russian), *Izmerit. tekhnika* no. 3, 42–46, 1955; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6805.

In order to study the viscosity of liquids at pressures up to 5000 kg/cm², a viscometer with a falling sphere is used. The working duct has capillary pipes at each end which center the sphere. The length of the no-load condition of the sphere in the capillary is selected in such a way that the motion of the sphere on the section between the observation windows in the body is uniform. The falling time was determined visually with the aid of a stop watch.

Determination of the viscosity was effected according to the Stokes-Ladenburg and Stokes-Faksen formulas [G. Barr, "Viscosimetry," GONTI, 1936]. The limits of application of these formulas are investigated for the given instrument, and also corrections for the density variation of the sphere and of the liquid and deformation of the instrument due to the pressure.

The results are given of the investigation of the viscosity of vaseline, transformer, castor, turbine, and all spindle oils, and also Groznenskii MS oil of high and normal viscosity, glycerine and siloxane at 14, 20 and 30°. It is shown that, for the liquids investigated, the exponential formula $\eta = \eta_0 e^{\beta P}$ at values of the piezo-coefficient β calculated by the author gives an error of up to 6–15% compared with the experiment. S. A. Regirer

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3238. Andrisyevsky, A. J., and Karelin, N. N., A viscometer for opaque liquids (in Russian), *Dokladi Lvovsk. politekhn. in-ta* 1, 1, 22–24, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7649.

The rate of fall of a metal ball in the test liquid is measured by the change in inductance of coils wound on the viscometer tube, produced by the passage of the ball. The design is not developed structurally. No data are given of the degree of accuracy with which the viscosity can be measured.

In regard to the change of inductance in a coil by passage of a metal ball, see also *Ref. Zh. Mekh.* 1956, Rev. 2326.

A. I. Golubev

Courtesy Referarivnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3239. Kestin, J., and Moszynski, J. R., An instrument for the measurement of the viscosity of steam and compressed water, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-237, 7 pp.

Noting the highly imperfect state of present knowledge regarding the viscosity of steam, paper describes an instrument designed for the measurement of the viscosity of steam and compressed water. The project, undertaken under the sponsorship of the ASME Steam Research Committee, aims at exploring the applicability of the method of observing small torsional oscillations of bodies of revolution to the purpose in hand.

From authors' summary

3240. Eisenberg, H., Rotation viscometer directly measuring the ratio of the shearing stress to the rate of shear, *Rev. sci. Instrum.* **28**, 11, 927–929, Nov. 1957.

A rotation viscometer, directly measuring the ratio of the shearing stress to the rate of shear, is described in detail. The reading for Newtonian liquids is independent of the speed of rotation and, for non-Newtonian liquids, gives a direct indication of the dependence of the apparent viscosity on the rate of shear. The principle of the measurement is as follows: A slit, the width of which is proportional to the shearing stress, rotates together with the rotating cylinder of the viscometer; a narrow beam of light passes through this slit and falls on a photoelectric cell; the time of illumination of the photoelectric cell is proportional to the viscosity. The instrument may be used over a wide range of viscosities and rates of shear. From author's summary

3241. Evans, R. A., New method of flow visualization for low-density wind tunnels, *J. appl. Phys.* **28**, 9, 1005–1010, Sept. 1957.

A new method of visualizing low-density flows is described which employs the absorption by oxygen of radiation in the wavelength region 1400 A to 1500 A. It was developed for use in the low-density supersonic continuous flow wind tunnels at Berkeley because the conventional methods (shadowgraph, schlieren, and interferometer) were predicted to have inadequate sensitivity at the unusually low densities in the test section. A xenon discharge is used for the source of radiation, its 1470 A resonance line being isolated by a calcium fluoride vacuum monochromator. A 26-mm diameter beam of parallel radiation is passed through the test section where it is absorbed more or less depending on the oxygen density along the radiation path. The center of the test section is then focused by a calcium fluoride vacuum camera on an ultraviolet-sensitive photographic plate. Pictures of shock waves from cylinders 1/8 and 1/4 in. in diameter and from a 60° 3/8-in. wedge were obtained with exposure times of about 4 minutes. Development of a stronger source would reduce the exposure time appreciably. This oxygen-absorption method is shown to be suitable, in principal, for general wind-tuneel work where the absolute pressures are below about 1 mm Hg. From author's summary

3242. Rhyne, R. H., Effects of airplane flexibility on wing strains in rough air at 35,000 feet, as determined by a flight investigation of a large swept-wing airplane, *NACA TN* 4198, 11 pp., + table + 11 figs., Jan. 1958.

A flight investigation was made on a large sweptback-wing bomber airplane and the results are compared with data previously obtained at low altitude (5000 feet). The effects of wing flexibility on the wing strains were, on the average, about 20% larger at the higher altitude. From author's summary

3243. Rhyne, R. H., and Murrow, H. N., Effects of airplane flexibility on wing strains in rough air at 5,000 feet as determined by flight tests of a large swept-wing airplane, *NACA TN* 4107, 14 pp. + 2 tables + 13 figs., Sept. 1957.

A flight investigation has been made on a large sweptwing bomber airplane in rough air at 5000 feet to determine the effects of wing flexibility on wing bending and shear strains. In order to evaluate the overall magnitude of the aeroelastic effects on the strains and their variation with spanwise location, amplification factors defining the ratio of the strains in rough air to the strains expected for a "rigid" and "quasi-rigid" airplane were determined. The results obtained indicate that the aeroelastic effects are rather large, particularly at the outboard stations. The effects of dynamic aeroelasticity appear to increase the strains from 0 to 170%, depending upon the spanwise station. On the other hand, the relieving effects of static aeroelasticity appear to reduce the strain amplification in rough air by a significant amount.

From authors' summary

3244. Davenport, E. E., Wind-tunnel investigation of external-flow jet-augmented double-slotted flaps on a rectangular wing at an angle of attack of 0° to high momentum coefficients, *NACA TN* 4079, 31 pp., Sept. 1957.

A preliminary investigation of external-flow jet-augmented double slotted flaps on a rectangular wing with an aspect ratio of 6 has been made in the Langley 300-mph 7- by 10-ft tunnel. High-momentum air was blown from one and two nacelles over the double slotted flaps of 30% wing chord incorporating vanes of either 58.3% or 20% of the flap chord.

Lift coefficients larger than the jet reaction in the lift direction were attained with the external-flow jet-augmented double slotted flaps. Over the lift-coefficient range investigated, these flaps produced about 80% of the lift produced by the jet-augmented plain flap investigated in *NACA TN* 3865. The lift coefficients for configurations incorporating an inboard nacelle, a midspan nacelle, or twin nacelles were about the same throughout the momentum-coefficient range tested.

With the center of moments at 25% wing mean aerodynamic chord, large negative pitching moments were found to exist for the double-slotted-flap configurations which were comparable with those produced by the jet-augmented plain flap previously investigated. The loss in lift needed to trim these pitching moments for a tail located 2 wing chords behind the wing was estimated to range from 7.5% to 27.5% of the total wing lift. From author's summary

3245. Vogler, R. D., and Turner, T. R., Wind-tunnel investigation at low speeds to determine flow-field characteristics and ground influence on a model with jet-augmented flaps, *NACA TN* 4116, 48 pp., Sept. 1957.

A wind-tunnel investigation has been made at low speeds to determine the flow-field characteristics and ground influence on an airplane model having an untapered, unswept wing with an aspect ratio of 8.3 equipped with jet-augmented flaps. Jet-augmented-flap deflections of 55° and 85° were investigated with the jet-blowing energies covering a range representative of that of the output of current jet airplanes. The high lift coefficients associated with the jet-augmented flaps were greatly reduced when the wing was in the proximity of the ground. The adverse effects of the ground increased rapidly as the wing approached the ground, as the jet-deflection angle increased, or as the momentum coefficient increased. Associated with these reductions in lift coefficient were reductions in both drag coefficient and nose-down pitching-moment coefficient. No ground effect was noted on the model with either a jet-augmented-flap deflection of 55° when the model was mounted higher than 3 chords above the ground or with a jet-augmented-flap deflection of 85° when the model was mounted more than 5 chords above the ground.

High angles of downwash were measured for downstream locations considered of interest for conventional tail locations. The jet-augumented full-span flap produced wing-tip vortices that increased in strength as the jet momentum coefficient increased and resulted in angles of upflow as large as 20° at a location 3 chords behind the wing-tip region. From authors' summary

3246. Brenckmann, M., Experimental investigation of the aerodynamics of a wing in a slipstream, *Univ. Toronto Inst. Aerophys. TN* 11, 14 pp. + 22 figs., Apr. 1957.

An experimental study of a wing in a propellar slipstream was made to determine the distribution of the lift increase due to slipstream at different angles of attack of the wing and at different free stream-slipstream velocity ratios, the results being intended as an evaluation basis for different theoretical treatments of this problem.

During this study it was found that the main departure from the potential flow expectation occurs at large angles of attack, where a destalling effect of the slipstream on the whole wing results in significant additional lift. Measurements of center of pressure shift were made to clarify this point.

In other respects potential flow representation of the phenomenon seems justified, provided slipstream rotation is taken into account when solving for the spanwise lift distribution. In terms of total lift gain, a closed form solution given by a slender-body theory showed good agreement with experimental values from which destalling effects were subtracted. From author's summary

3247. Schmidt, R. D., Vasu, G., McGraw, E. W., Determination of surge and stall limits of an axial-flow turbojet engine for control applications, *NACA TN* 3585, 29 pp., Sept. 1957.

During the course of an investigation of an axial-flow turbojet engine in the Lewis altitude wind tunnel, limitations on the transient operation of the engine were determined in relation to two altitudes and exhaust-nozzle-areas. Below approximately 70% of the generalized engine rotational speed, a high-frequency oscillation (stall) at the compressor inlet limited transient operation of the engine. Over 70% of the engine speed, transient operation was limited by a low-frequency oscillation (surge), which occurred throughout the engine.

The data presented are the result of an analysis of oscillograph traces obtained when the engine was operated off steady state by introducing either a step increase or a ramp increase in fuel flow. For a given speed, a lower fuel flow was required for the engine to recover from surge or stall than was necessary for surge or stall to occur. Very little difference existed between the surge line (compressor pressure ratio against engine rotational speed) obtained under transient conditions and that obtained under steady-state conditions by decreasing the flow area with an adjustable first-stage turbine stator. From authors' summary

3248. Hall, I. M., The operation of the N.P.L. 18-in. × 14-in. wind tunnel in the transonic speed range, *Aero. Res. Counc. Lond. curr. Pap.* 338, 9 pp. + 12 figs., 1957.

3249. Murasaki, T., Calibration of transonic wind tunnel by measuring loads of a double wedge profile, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 283–286.

3250. Wurster, W. H., Final report summarizing research in rate of high-speed reactions, Cornell aero. Lab. Rep. AD-959-A-2, 11 pp. + 8 figs., Jan. 1958.

Report is a final summary of work done in single-pulse shock tube investigation of the kinetics of the reaction $N_2 + O_2 \rightleftarrows 2\,NO$ between 2000 K and 3000 K. The results are consistent with chain mechanism proposed by Zeldovich; and an activation energy of 74 ± 5 kcal/mole was measured. A complementary investigation of the dissociation rate of O_2 showed this latter rate to be much faster than some theories had predicted and fast enough to be consistent with the chain mechanism for NO formation. The details of these investigations have been published in *J. chem. Phys.* **27**, p. 850, 1957; ibid **27**, p. 1224, 1957; and "Fifth Symposium (International) on combustion," Reinhold Publishing Corp., New York (1955), p. 393. R. E. Duff, USA

3251. Wittliff, C. E., and Wilson, M. R., Shock tube driver techniques and attenuation measurements, Cornell aero. Lab. Rep. AD-1052-A-4, 34 pp., Aug. 1957.

Report is an interesting if not profound comparison of shock-wave attenuation and pressure profiles as function of high-pressure driver used. The four driving techniques compared are those using constant pressure and constant volume combustion of $H_2 + O_2 + H_e$ mixtures and cold, high pressure H_2 or H_e. Results are presented which show that shock-wave attenuation is directly related to the efficiency of the driver used; that found with a constant-pressure combustion driver was more than an order of magnitude more severe than that produced by high-pressure H_e driver. The importance of considering driver flow in theory of shock-wave attenuation in shock tube is stressed. Pressure profiles showed a decrease in pressure behind shocks produced with constant pres-

sure combustion and a severe increase in pressure behind shocks produced by constant volume combustion. The profiles from the cold drivers both showed a short region of relatively constant pressure followed by a region of increasing pressure.

R. E. Duff, USA

3252. Mullaney, G. J., Shock tube technique for study of auto-ignition of liquid fuel sprays, *Indust. Engng. Chem.* **50,** 1, 53-58, Jan. 1958.

A window section in the shock tube permits study of the auto-ignition process with high-speed photography.

From author's summary

3253. Oshima, K., Preliminary investigation of the strain gauge balances for shock tube experiments, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 273-276.

3254. Glass, I. I., and Hall, J. G., Determination of the speed of sound in sulfurhexaflouride in a shock tube, *J. chem. Phys.* **27,** 5, p. 1223 (Letters to the Editor), Nov. 1957.

3255. Ashwood, P. F., Crosse, G. W., and Goddard, J. E., Measurements of the thrust produced by convergent-divergent nozzles at pressure ratios up to 20, *Aero. Res. Counc. Lond. curr. Pap.* 326, 13 pp. + 2 appendixes + 10 figs., 1957.

Thermodynamics

(See also Revs. 2962, 3153, 3162, 3164, 3197, 3207, 3208, 3210, 3214, 3301, 3315, 3316, 3318, 3319, 3343)

Book—3256. Weber, H. C., and Meissner, H. P., Thermodynamics for chemical engineers, 2nd ed., New York, John Wiley & Sons, Inc., 1957, vi + 507 pp. **$8.50**

This book on chemical engineering thermodynamics by Professors Weber and Meissner is a revised edition of an earlier book (1939) of the same title by Professor Weber alone. The authors' experience in teaching thermodynamics to chemical engineering students at MIT since the first edition appeared has been profitably used in making this new book more valuable as a text and reference. Specifically, new problems have been added and, what is more important, a greater effort is made to help students gain an intelligent grasp of the fundamentals of this somewhat elusive and hard-to-teach subject. Several sample problems are worked out explicitly in the text, a teaching device which seems singularly appropriate in a practical thermodynamics text.

The subject matter is found to be fairly typical of engineering thermodynamics texts: the first and second laws, thermodynamic properties of materials, equations of state, solutions, physical and chemical equilibrium and related concepts such as free energy, entropy, fugacity and activity. In addition, several applications are treated: engines, turbines, refrigeration and electrolytic cells. An elementary discussion of fluid flow in pipes and nozzles is also included.

Hougen and Watson's method for estimating the free energy of formation of organic compounds on the basis of molecular structure [Hougen and Watson, "Chemical process principles," Vol. 2] might well have been included in the present book. Hottel's somewhat analogous method for heats of formation, however, is given in full detail.

Certain areas of applied thermodynamics which are of some importance in chemical engineering practice have been rather neglected. For example, surface tension effects on fugacity, the Gibbs adsorption isotherm, osmosis and membrance equilibria seem to have been ignored altogether. This reviewer was unable to find any explicit discussion of boiling-point elevation, freezing-point depression, eutectics, and azeotropes. The treatment of electrolytes is exceedingly meagre. No mention is made of ionization constants, solubility products and activity coefficients in electrolyte solutions. Although these topics are usually labelled "physical chemistry," they do constitute very direct applications of thermodynamics to chemical engineering unit operations: crystallization, extraction, dialysis and distillation. As such, these matters deserve some consideration in a book of this title, at the expense perhaps of the discussion of engines, turbines and fluid dynamics, all of which are more fully covered elsewhere.

The emphasis on thermodynamic fundamentals in this book is valuable, but the selection of applied thermodynamics topics presented seems to this reviewer to be rather unbalanced.

A. W. Gessner, USA

3257. Barnes, G., Patmore, J. W., and Fountain, S. J., Classification of collisions; elastic collisions on a macroscopic scale, *Amer. J. Phys.* **26,** 2, 122-127, Feb. 1958.

A number of well-known physics textbooks imply, and some state definitely, that perfectly elastic collisions never occur. It is pointed out that collisions between atoms and molecules are frequently elastic. A classification of collisions into three groups, depending upon the nature of the interaction forces, indicates that certain kinds of collisions between macroscopic objects may be perfectly elastic. Simple laboratory experiments illustrating two of these cases are described.

From authors' summary

3258. Hirschfelder, J. O., The anatomy of molecular physics, Univ. Wisc. Nav. Res. Lab., (5) CN 915, 11 pp., Oct. 1957.

An effort is made to explain the interrelations between the fundamental laws of physics, the molecular properties, the bulk properties of materials, and the various types of experimentation. These interrelations are becoming extremely important as our interests widen to encompass extreme conditions of temperature, pressure, etc., and as our experimentation becomes more precise.

From author's summary

3259. Burrows, G., and Preece, F. H., The process of gas evolution from low vapour pressure liquids upon reduction of pressure, *Trans. Instn. Chem. Engr.* **32,** 2, 99-114, 1954.

The process of gas evolution from a quiescent supersaturated liquid is discussed and equations, based on a similarity with heat transmission, are derived which express the rate of gas evolution in terms of solubility and diffusivity. Apparatus suitable for verifying the equations is described and the results of tests are given.

It is shown how, with increasing supersaturation, bubble formation can be initiated, the degree of bubbling being dependent on a variety of factors. A method of calculating the final size of the bubbles on reaching the liquid surface is given.

Experimental results of gas evolution under bubbling conditions are described, and equations are deduced from which the rate of gas evolution and degree of bubbling can be calculated for a given gas in a given liquid, within the range investigated.

From authors' summary

3260. Saunders, P. M., The thermodynamics of saturated air: a contribution to the classical theory, *Quart. J. roy. meteor. Soc.* **83,** 357, 342-350, July 1957.

In most meteorological applications little differentiation is made between reversible and irreversible changes of state. This lack of preciseness is justified since the meteorologist is usually after only a first approximation to the atmospheric stability. However, it is important to realize that changes of state of rising saturated air need not be along the pseudo-adiabats, so conveniently presented on the pseudo-adiabatic diagram. Further, when more pre-

cise analyses of rising saturated air are required, particularly when a change of phase of the suspended condensed water droplets occurs (which is impossible with the pseudo-adiabatic assumption), then one should revert to the original expansion equations, or to prepared tables or graphs showing the relationship between saturation pseudo-adiabatic (irreversible) and saturation adiabatic (reversible) expansions.

The above information is usually stressed in any college course on atmospheric thermodynamics; however, the tables and graphs have been lacking. If for no other reason, this article is of interest and importance since it places in print (in a readily available publication) graphs showing the relationships between reversible and irreversible expansions for both water and ice saturation conditions. In addition, allowance is made for the existence of supercooled liquid water droplets, the known occurrence of which is usually neglected in the classical development.

The author then goes on to give a specific example of the importance of his graphs by deriving a relationship which he calls "cloud virtual temperature." He shows that in-cloud temperatures are less for the reversible than for the irreversible water saturation adiabatic process, but that the heat release during the freezing of suspended liquid water (during reversible expansion) appears to cause quite sudden growth of cumulus clouds.

This article should be understood by anyone who has had a course in atmospheric thermodynamics. Reference may be made to most any atmospheric thermodynamic textbook for the derivation of the equations given in the article. N. K. Wagner, USA

3261. Hahnemann, H. W., Approximative calculation of heat conduction coefficent of nonpolar gas mixtures (in German), *Forsch. Geb. Ing.-Wes.* **22,** 1, p. 35, 1956.

3262. Golde, H., Calorimeter for the measurement of the specific heat of vapours. The specific heat of isobutyl alcohol vapours, *Feingerätetechnik* **6,** 4, 159–163, Apr. 1957.

3263. Nuttall, R. L., and Ginnings, D. C., Thermal conductivity of nitrogen from 50° to 500°C and 1 to 100 atmospheres, *J. Res. nat. Bur. Stands.* **58,** 5, 271–278, May 1957.

3264. Logan, J. G., Jr., and Treanor, C. E., Polytropic exponents for air at high temperatures, *J. aero. Sci.* **24,** 6, 467–468 (Readers' Forum), June 1957.

3265. Liley, P. E. Isotherm measurements and their application to the computation of thermodynamic data, *J. Imperial College chem. Engng. Soc.* **7,** 69–85, 1953.

3266. Lutz, O., Examples of application of reaction kinetics thermodynamics (in German), *Jahrbuch Wiss. Gessellsch. Luftfahrt* 11–19, 1956.

3267. Riccoboni, L., Oleari, L., and Fiorani, M., Thermodynamics of two-phase liquid metals (in Italian), *Metallurgia ital.* **12,** 10, 725–744, Oct. 1957.

A review of experimental methods for determination of activity of components in a liquid metal system. Authors show that results are useful for the calculation of free energy and of their thermal coefficients of mixtures of two components.

C. Codegone, Italy

3268. Eastabrook, J. N., Thermal expansion of solids at high temperature, *Phil. Mag.* (8) **2,** 24, 1421–1426, Dec. 1957.

In a theory of thermal expansion above the Debye temperature, the increases of specific heat and Gruneisens' ν with temperature are taken into account. The increase of expansion coefficient with temperature observed in several simple substances is shown to be about that expected for a perfect crystal. It is not evidence for the thermal generation of defects in the crystal.

From author's summary

3269. Waterman, H. I., and Wolfs, P. M. J., Accurate measuring of the density of solids, using helium as a gaseous medium, *Appl. sci. Res.* (*A*) **6,** 5/6, 372–384, 1957.

For an investigation of chemical and physical properties of matter, density can be a valuable expedient. Up to now, methods for the determination of the density of solids, e.g. powders, generally give an accuracy not better than $\pm 5\%$. In this paper an apparatus is described allowing to determine the density of solids with an accuracy of at least $\pm 0.2\%$.

The principle of the method is that a constant volume of a gaseous medium is displaced by the sample, which displacement is measured by weighing the corresponding volume of mercury. To keep the volume of the gas sufficiently constant,, a compensation-manometer is used, which enables to counterbalance the influence of fluctuations in temperature and pressure.

Helium is used by preference, because this gas is considered to give the least complications in comparison with other media.

From authors' summary

3270. Williams, D. A., Chung, R., Lof, G. O. G., Fester, D. A., and Duffie, J. A., Intermittent absorption cooling systems...with solar regeneration, ASME Ann. Meet., New York, N.Y., Dec. 1957. Pap. 57-A-260, 13 pp.

A discussion of the principles involved, of ideal refrigerant requirements, and of the merits of various known refrigerants is followed by a theoretical and experimental evaluation of ammonia-water, and Freon-glycol-ether systems. Paper represents a pioneer contribution to research in this field of solar energy utilization and merits careful study by all concerned with solar refrigeration. A. Whillier, South Africa

3271. Niebergall, W., Absorption heat pumps, *Kältetechnik* **9,** 8, 238–243, Aug. 1957.

3272. Bata, G. L., Recirculation of cooling water in rivers and canals, *Proc. Amer. Soc. civ. Engrs.* **83,** HY 3 (*J. Hydr. Div.*), Pap. 1265, 28 pp., June 1957.

The recirculation of water after it has been used as a coolant in thermoelectric plants and returned to the river or canal from which it was originally drawn is of great importance to the economy of operation of such plants. Among the many factors that affect the amount of recirculation, the most important ones are the channel depth and discharge, the distance between intake and outlet of the flow diverted for cooling, the degree of heating of the diverted water, and the relative amount of diversion. The effects of these factors have been singled out for an extensive analytical and experimental study, the results of which, together with design criteria derived therefrom, are presented in this paper.

From author's summary

3273. Unger, S., Improvement of the thermodynamic cycle of air-ammonia absorption refrigerator through the application of a dilute salt solution as absorption media (in German) *Technik* **12,** 2, 119–127, Feb. 1957.

3274. d'Epinay, J. L., and Lundgren, C. E., Heat engines in atomic power stations (in German), *Schweiz. Bauztg.* **75,** 18, 278–282, May 1957.

3275. Weaving, J. H., and Carelli, A., Gas-turbine automobiles, *Mech. Engng., N. Y.* **79,** 7, 643–647, July 1957.

Heat and Mass Transfer

(See also Revs. 2962, 3028, 3126, 3172, 3174, 3203, 3256, 3260, 3261, 3270, 3363, 3364)

3276. Jain, S. C., Simple solutions of the partial differential equation for diffusion (or heat conduction), *Proc. roy. Soc. Lond.* (*A*) **243,** 1234, 359–374, Jan. 1958.

Solution of title equations with appropriate initial and boundary conditions over a finite domain can often be expressed as an infinite series which arises from the Fourier expansion of the initial distribution. Convergence is usually quite slow unless time is large. In a number of problems it is known that for the initial stages, at least, a good approximation is afforded if one replaces the finite domain solution by a semi-infinite one. Here the solutions are often simple and facilitate interpretation of test data. This suggests that relation between behaviors of solutions for semi-infinite and finite domains be studied in detail to determine conditions of validity for substituting the former for the latter. Paper develops a method for obtaining general solutions of partial differential equations in terms of those applicable to linear diffusion in a semi-infinite slab. The technique is applicable to diffusion in one, two, or three dimensions, in solids of various shapes and under different boundary and initial conditions. Examples treated are the rectangular parallelopiped, cylinder, and sphere. The case of linear diffusion in a finite slab when the material is generated inside it at a constant rate is considered. Numerical results are exhibited comparing Fourier series solution with method of paper. Agreement is very good.

Y. L. Luke, USA

3277. Harrison, W. B., Boteler, W. C., and Barnett, S. C., Thermal diffusivity of gases as determined by the cyclic heat transfer method, ASME Ann. Meet., New York, N.Y., Dec. 1957. Pap. 57-A-193, 10 pp.

A method and the corresponding apparatus are described by which the thermal diffusivity of gases can be measured by determining either the phase shift or the degree in amplitude of a sinusoidal temperature fluctuation as it penetrates radially inward in a cylindrical gas layer. Two platinum resistance wires measure the temperature fluctuations at two radial positions in the gas which fills a pipe of 1-in. diam. and 33-in. length. The temperature fluctuation is produced by a varying electrical current through the pipe wall. An evaluation of the procedure has to await the publication of test results.

E. R. G. Eckert, USA

3278. Cooper, M., and Mayo, E. E., Normal conduction effects on heat-transfer data during transient heating of thin-skin models *J. aero. Sci.* **24,** 6, 461–462 (Readers' Forum), *June 1957.*

One of the most commonly used methods to determine aerodynamic heat-transfer data is to expose a thin-skin model to a heated air stream. The heat-transfer coefficients are then evaluated by balancing the rate at which heat enters a unit volume of the skin with the rate at which heat is stored and leaves the skin. It is usual to minimize the skin thickness to keep the temperature difference across the skin negligible and the lateral conduction as small as possible. The use of a thin skin introduces structural problems, particularly for blunt noses, where the pressure may be sufficient to warp or fail the structure. To overcome this difficulty, it is common to use a fill material for added strength with the hope that only little heat may flow out the back face of the skin. It is the purpose of this note to establish the magnitude of the error involved by neglecting the presence of a fill material to show that, even for the best of fill materials, the errors might be quite significant.

From authors' summary

3279. Hurwicz, H., and Tischer, R. G., Heat transfer in canning, *Mech. Engng.* **79,** 10, p. 924, Oct. 1957.

3280. Shil'krut, D. I., Problem of thermal conductivity of two media (in Russian), *Prikl. Mat. Mekh.* **20,** 2, 284–288, Mar.-Apr. 1956.

3281. Kayan, C. F., Heat flow temperature patterns of complex structures by resistance concept and electrical analogy (in English), *Varmestromsgruppen* **2,** 1, 17–35, 1956.

3282. Barzelay, M. E., and Holloway, G. F., Interface thermal conductance of twenty-seven riveted aircraft joints, *NACA TN* 3991, 23 pp., July 1957.

3283. Bourne, D. E., and Davies, D. R., Heat transfer through the laminar boundary layer on a circular cylinder in axial incompressible flow, *Quart. J. Mech. appl. Math.* **11,** 1, 52–66, Feb. 1958.

The boundary layer on the external surface of a cylinder with axis parallel to the flow is considered. The surface temperature and fluid properties (density, viscosity, and thermal conductivity) are assumed constant, and viscous heating is neglected. The authors derive an asymptotic solution valid for large downstream distances and an approximate solution to bridge the gap between the asymptotic solution and a series solution valid for small downstream distances, which had been obtained previously by Seban and Bond [AMR **5** (1952), Rev. 1161] and Kelly [AMR **8** (1955), Rev. 728]. The effects of curvature and Prandtl number on the local heat transfer at various downstream distances are demonstrated by comparison with the corresponding flat-plate results.

D. W. Dunn, Canada

3284. Ko, S.-Y., Calculation of local heat-transfer coefficients on slender surfaces of revolution by the Mangler transformation, *J. aero. Sci.* **25,** 1, 62–63 (Reader's Forum), Jan. 1958.

Author extends the Mangler transformation in order to evaluate local heat-transfer coefficients on a slender body of revolution in an incompressible stream with constant fluid properties. In particular, local heat-transfer coefficients were determined for flow past a semi-ellipsoidal body of fineness ratio 4 : 1. Mean heat-transfer coefficient is determined from an integration of local values over the surface.

A. Ritter, USA

3285. Niven, C. D., The heat transmission of fabrics in wind, *Text. Res. J.* **27,** 10, 808–811, Oct. 1957.

Two samples of overcoating material were tested for heat transmission in wind when an air space under the material was provided. The effect of a wind breaker both under and over the material was observed. The work shows that when a sample has a high permeability to air and does not lie close to the hot plate, there is a very marked difference between the results obtained with a wind blowing parallel to the surface and those with the wind striking the surface at 45°. The work also proves that the thermal insulation afforded by a fabric or combination of fabrics in wind depends on what is underneath the sample and suggests that some purely arbitrary test procedure, specified by a standardizing authority, may be desirable.

From author's summary

3286. Hsu, N. T., and Sage, B. H., Thermal and material transfer in turbulent gas streams: local transport from spheres, *AIChE J.* **3,** 3, 405–410, Sept. 1957.

Local and gross rates of heat transfer were found for two one-half-in. diam spheres, one of silver and the other of porous ceramic, in the Reynolds number range from 1530 to 4200 based on the sphere diameter. Stream turbulence was about 5.4%. The local rates of heat transfer were calculated from radial temperature gradients of the stream adjacent to the surface. The temperature gradients were obtained from temperatures measured by a

traversing thermocouple. The gross rate of heat transfer without material transfer was obtained from electrical energy added to the silver sphere, and that with material transfer from the amount of *n*-heptone evaporated from the porous sphere. Integration of the local rate of heat transfer agreed well with the gross rate of heat transfer. The experimental local heat transfer is compared with several theoretical analyses based on boundary-layer theory and the agreement is good. N. Tetervin, USA

3287. Reichardt, H., The principles of turbulent heat transfer, *NACA TM* 1408, 45 pp., Sept. 1957.

Relations are derived for calculating heat-transfer coefficients for turbulent and laminar fully developed flow and heat transfer in pipes and channels at constant wall temperature. Nusselt numbers for a round pipe are computed for Prandtl numbers from 0 to 1000 at a Reynolds number of 30,000. The eddy diffusivity of momentum is assumed to vary in a continuous manner from the wall to the center of the channel. For very high Prandtl numbers it is postulated that the eddy diffusivity of momentum varies with the fifth power of the distance from the wall when very close to the wall.

From author's summary

3288. Schulenberg, F., Application of air cooling, taking into consideration the heat exchange in elliptical fin tubes (in Dutch), *Ingenieur* **69,** 32, 97-104, Aug. 1957.

3289. Dickinson, N. L., and Welch, C. P., Heat transfer to supercritical water, ASME-AIChE Conf., University Park, Pa., Aug. 1957. Pap. 57-HT-7, 7 pp.

Heat-transfer coefficients for supercritical water are presented for flow in an electrically heated AISI Type 304 stainless-steel tube having an inside diameter of 0.300 in. Bulk fluid temperatures were varied from 220 to 1000 F at 4500 psi, and over a more limited temperature range at 3500 psi. Mass flows tested include 1.6 to 2.5 × 10⁶ lb/hr-sq ft, and a flux range of 280,000 to 580,000 Btu/hr-sq ft was covered. Values of film conductance in the vapor region were found to be substantially higher than those predicted by extrapolation of data found in the literature, or by recent formulas based on a theoretical approach. These findings are of special interest to the boiler industry, which is presently designing units for use at supercritical conditions.

From authors' summary

3290. Rickard, C. L., Dwyer, O. E., and Dropkin, D., Heat-transfer rates to cross-flowing mercury in a staggered tube bank—II, ASME-AIChE Heat Trans. Conf., University Park, Pa., Aug. 1957. Pap. 57-HT-11, 7 pp.

Paper describes an experimental program which considers the effects of Reynolds number, Prandtl number, wetting, gas entrainment, and tube location on heat-transfer rates for mercury flowing crosswise through a tube bank of 60 ½-in. tubes in an equilateral-triangular array. Results in part cover material presented in the first paper of the series [AMR **11** (1958), Rev. 290] but present data are more extensive and believed to be more accurate. Prandtl number range is 0.014 to 0.022 and Reynolds number range is 20,000 to 200,000. For a tube in the interior of the bank, the Nusselt number is obtained as function of the Peclet number alone, $Nu = 4.03 + 0.228\,(Pe)^{0.67}$. Some additional results are presented for water flow through the same equipment. Pressure-drops through the bank are obtained for both the mercury and the water flow.

P. Chiarulli, USA

3291. Tomotika, S., and Yosinobu, H., On the convection of heat from cylinders immersed in a low-speed stream of incompressible fluid, *J. Math. Phys.* **36,** 2, 112-120, July 1957.

The case of two-dimensional heat transfer from a cylinder in a slowly moving stream is treated. Idealizations include fluid incompressibility, absence of eddy processes and viscous effects, and constant heat capacity and thermal conductivity. The usual differential equation for heat transfer in a moving stream is transformed into Mathieu functions. These are in turn solved to give the temperature distribution in the fluid. Heat transfer from the cylinder is obtained by integration of the temperature gradient over the cylinder surface. In addition to the exact solution, asymptotic solutions with their limits of application are given.

T. J. Connolly, USA

3292. Sparrow, E. M., and Gregg, J. L., Summary of low-Prandtl-number heat-transfer results for forced convection on a flat plate, *J. aero. Sci.* **24,** 11, 852-853 (Readers' Forum), Nov. 1957.

3293. Sparrow, E. M., and Gregg, J. L., The variable fluid-property problem in free convection, *Trans. ASME* **80,** 4, 879-886, May 1958.

An analysis is made for the variable fluid-property problem for laminar free convection on an isothermal vertical flat plate. For a number of specific cases, solutions of the boundary-layer equations appropriate to the variable-property situation were carried out for gases and for liquid mercury. Utilizing these findings, a simple and accurate shorthand procedure is presented for calculating free-convection heat transfer under variable-property conditions. This calculation method is well established in the heat-transfer field. It involves the use of results which have been derived for constant-property fluids, and of a set of rules (called reference temperatures) for extending these constant-property results to variable-property situations. Results are also presented for boundary-layer thickness and velocity parameters.

From authors' summary by H. D. Block, USA

3294. Chandrasekhar, S., The thermal instability of a rotating fluid sphere heated within. II. *Phil. Mag. (8)* **2,** 22, 1282-1284, Oct. 1957.

The eigenvalue problem specifying the state of marginal stability for the configuration considered was treated by standard methods in a previous paper [Chandrasekhar, S., *Phil. Mag. (8)*, **2,** no. 19, July 1957]. The solution presented therein is, however, found for a slightly modified set of boundary conditions for the case when the motions and associated perturbations are symmetric with respect to the rotational axis.

In the present paper the problem with the same symmetry conditions is reformulated in terms of a variational principle. It is anticipated that a more vigorous solution can be obtained in this way. S. Ostrach, USA

3295. Gebhart, B., Unified treatment for thermal radiation transfer processes—gray, diffuse radiators and absorbers, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-34, 14 pp.

Relations are given for steady-state radiative transfer in a general enclosure—a system of many gray surfaces. Author straightforwardly sets up the linear equations to be solved for the heat loss and general absorption factor for each surface. Special cases are described based on the occurrence of a "window", adiabatic surface, or transparent absorbing medium.

Treatment may be a contribution to the set-up of a complex problem. However, the major difficulty—determining angle factors in such problems—is not discussed. Author's paper and treatment given by Jakob, "Heat transfer," Volume 88, may be a useful combination. M. Gilbert, USA

3296. Gardon, R., and Michalik, E. R., Radiant heating of transparent materials, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-51, 13 pp.

An analytical solution is presented for the time and position-dependence of temperatures in transparent sheets heated by ther-

mal radiation. The results are exhibited in dimensionless graphical form, and their physical significance is discussed. In particular, comparisons are made between the heating of transparent and opaque materials, and between materials in the form of sheets, or slabs of finite thickness, and semi-infinite solids. The results are illustrated by an example. This considers temperature distributions in glass plates during initial stages of heating in a furnace. From authors' summary by H. D. Block, USA

3297. Vollmer, J., Study of the effective thermal emittance of cylindrical cavities, *J. opt. Soc. Amer.* **47,** 10, 926-932, Oct. 1957.

An equation is derived which relates the effective emittance of a cylindrical cavity to the emittance of the construction material, the ratio of the length to the radius of the cylinder, and the distance separating the cylinder and the receiver. This equation was checked by measuring the effective emittance of shallow cylinders of two different lengths, at four axial distances, and with three filter systems. The use of filters in combination with a construction material whose spectral emittance varies sharply is equivalent to varying the emittance of the construction material. In all cases considered, the experimental result and the value predicted are in agreement within the experimental limits.

From author's summary

3298. Parolini, G., Theory and experimental results on the radiant energy emission from thin layers of bad conducting materials supported by good conducting ones. Part I (in Italian), *Termotecnica* **10,** 5, 191-202, May 1956.

3299. Faneuff, C. E., McLean, E. A., and Scherrer, V. E., Some aspects of surface boiling, *J. appl. Phys.* **29,** 1, 80-84, Jan. 1958.

An experiment is described in which the growth of vapor bubbles at a surface is followed in detail. Growth curves are obtained and shown to agree, within experimental error, with current theories of growth under idealized conditions, provided an average superheat present at the initiation of growth is used in the calculation. A criterion is proposed to permit an estimate of a delay time for vapor formation. The estimated delays are found to be in qualitative agreement with those measured.

From authors' summary by W. M. Rohsenow, USA

3300. Camack, W. G., and Forster, H. K., Test of a heat transfer correlation for boiling liquid metals, *Jet Propulsion* **27,** 10, 1104-1106, Oct. 1957.

Equation [3] of this paper is derived for various fluids at burnout conditions. There is no reason to expect that the q/A versus ΔT relation it represents would necessarily be valid away from the burnout conditions. In fact, the slope of 2 suggested by Eq. [3] for the $\ln(q/A)$ versus $\ln(\Delta T)$ relation is generally low. This equation, as applied to heat-transfer data below the burnout point, is discussed by the reviewer in a discussion of the paper by Zuber in *Trans. ASME* Apr. 1958.

Its reasonable success in correlating the liquid metal data presented here lies perhaps in the fact that the normal boiling heat flux, with a $\ln(q/A)$ versus $\ln(\Delta T)$ curve slope of around "3", is augmented by a significant superimposed conduction heat flux for which the $\ln(q/A)$ versus $\ln(\Delta T)$ curve has a slope of unity. The net result is a varying slope around 2. The correlation for this data is good. Reviewer feels, however, that a general correlation must have a term which depends on surface conditions.

W. M. Rohsenow, USA

3301. Kamev, G. F., Investigation of a working process in condensers by using the method of hydraulic small-scale models of nests of tubes (in Russian), *Trudi Vses. nauch. inzh.-tekhn. o-va sudostroeniya* **6,** 3, 50-65, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 716.

Results are published of the experimental study of the movement of a vapor-air mixture in the inter-tube spaces of a condenser. The investigation is carried out by the method of gas hydrodynamic analogy, i. e., on the basis of the displacement of a two-dimensional flow of gas by a flow of liquid in an open stream (with the power of kinematic identity of both flows, affiliated with the corresponding relationship between their parameters). During the flow of the vapor-air mixture in the condenser, the quantity of vapor, in consequence of condensation, gets smaller along the stream. This effect, which is imitated by the discharge of liquid inside the tubes (through slits made in corresponding manner), has a highly important meaning for the process in the model, inasmuch as the analogues of the basic parameters of the gaseous flow are expressed through the liquid level. In this way the problem becomes complicated to a strong extent, and the conditions of modelling can only be given approximately, on the basis of the preliminary calculation, the results of which are brought into use in correspondence with the experimental data by means of a successive approximation. The author notes that satisfactory agreement is obtained after only two to three approximations.

A. A. Gukhman

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3302. Lyuboshits, I. L., Investigation of a new method of grain-drying (in Russian), *Trudi in-ta energetiki Akad. Nauk BSSR* no. 2, 114-161, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 661.

Results are given of an industrial investigation initiated by the author for a new method of grain-drying in a suspended state, the principal feature of which is the discontinuity of the drying process. The results of tests of the experimental, industrial-scale grain-drier, incorporating the proposed method of drying, showed a number of advantages in comparison with existing grain-driers.

V. D. Sokolov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3303. Belluigi, A., Complete dehydration of water saturated foils with the aid of electro-osmosis (in German), *Bautechnik* **34,** 1, 1-2, Jan. 1957.

3304. Sherwood, T. K., and Bryant, H. S., Jr., Mass transfer through compressible turbulent boundary layers, *Canad. J. chem. Engng.* **35,** 2, 51-57, Aug. 1957.

New data are presented on mass transfer to air at velocities up to 520 mps (Mach 2.02). These were obtained by measuring the rate of sublimation of naphthalene, thymol, and camphor from cylinders placed longitudinally in air streams in three subsonic and supersonic ducts.

Earlier published data are limited to air velocities of about 10 mps. These are collected and correlated as a graph of j_D versus Re, following Chilton and Colburn. The new subsonic data are found to fit this correlation.

At supersonic air velocities there is an important effect of Mach number, superimposed on the effect of Reynolds number. Both subsonic and supersonic data are correlated by introducing a function of Mach number similar to that found to apply to skin friction at supersonic velocities. The results lend semi-quantitative support to the conclusion that the effect of Mach number is the same for mass transfer and for skin friction.

From authors' summary

3305. Trey, F., Resistance thermometers from semiconductors (in German), *Radex Rundschau* no. 2, 519-524, 1957.

Resistance thermometers based on the characteristics of the semiconductors are now in use for technical purposes; the fundamental principles of the conductivity of semi-conductors were in-

vestigated by John Bardeen and William Shockley for Ge and Si. The production of ten semi conductors which are suited for thermometers and their sensitivity are discussed together with the possibility of their use in other domains.

From author's summary

3306. Mason, G. L., A fast-response resistance thermometer system for simultaneous recording of air temperature at a number of separated points, *Bull. Amer. meteor. Soc.* **38,** 7, 391–394, Sept. 1957.

A resistance-thermometer system is described which permits simultaneous and continuous recording of air temperatures at a number of separated points. Unbalance current in a Wheatstone bridge network is used as the measure of temperature, and is recorded by a multichannel light-beam oscillograph. The lag coefficient of the system is approximately 0.1 second.

From author's summary

3307. Kalasknikov, Ya. A., and Vereshchagin, L. F., Temperature measurement by radiation under high pressure and certain optical phenomena in gases under these conditions (in Russian), *Zh. Tekh. Fiz.* **26,** 8, 1802–1814, 1956 (translated by M. D. Friedman, Inc., 67 Reservoir St., Needham Heights, Mass.).

Authors constructed a photoelectric pyrometer to measure gas temperatures by measuring the radiation intensity of the hot gas. This pyrometer uses a zinc sulphide photoconductor as radiation receiver, which has a sensitivity of 5000–8000 μa/lumen with its maximum sensitivity at a wave length of 2.1μ. The spectrum that is received by the pyrometer ranges from about 0.75μ to 2.1μ. The measured temperatures ranged from 300 C to 550 C and the pressure range was 1 kg/cm^2 to 1500 kg/cm^2. The experiments were performed with nitrogen and argon gas.

In the authors' arrangement, the light from the hot furnace gas was passed through a tubular space to the radiation receiver, which was at room temperature. The temperature gradients and density inhomogeneities present in this tubular space were found to cause erroneous temperature measurements, especially at higher pressures. Authors conclude and prove by experiments that this difficulty can be overcome by the use of a solid body as a light conductor between the hot gas and the radiation receiver. After the authors inserted a quartz rod to serve as such a light conductor, they obtained simultaneous temperature measurements with their photoelectric pyrometer and with a suitably placed thermocouple, which show good agreement.

Ruth N. Weltmann, USA

3308. Huss, G., Estimation of operating range of heat telescopes (in English), *Varmestromsgruppen* **2,** 3, 11–19, 1956.

An object with a temperature different from its surroundings, as, for instance, an unwelcome supersonic bomber, involuntarily emits with the velocity of light information about its existence and position.

From author's summary

3309. Beczkoy, J., Computation of thermoelement-chains (in Hungarian), *Mérés és Automat.* **5,** 1, 28–31, 1956.

3310. Fateev, N. P., Acoustic method of measuring the atmospheric temperature (in Russian). *Tr. Gl. geofiz. observ.* no. 52, 48–61, 1955; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6807.

3311 & 3312. Conn, W. M., Accurate temperature measurements in work with solar furnaces, *Amer. J. Phys.* **24,** 8, 581–583, Nov. 1956.

3313. Glaser, P. E., Engineering research with a solar furnace, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-261, 5 pp.

3314. Zoller, R. E., Extended heat exchange surface for marine and nuclear boilers, *N. E. Cst. Instn. Engrs. Ship. Trans.* **74,** 4, 205–218, Feb. 1958.

3315. Bahnfleth, D. R., Chen, C. F., and Gilkey, H. T., Performance of small-pipe warm-air perimeter heating systems, *Univ. Ill. Engng. Exp. Sta. Bull.* no. 445, 35 pp., 1957.

3316. Hebrank, E. F., Investigation of the performance of automatic storage-type gas and electric domestic water heaters, *Univ. Ill. Engng. Exp. Sta. Bull.* 436, 39 pp., Oct. 1956.

3317. Panetti, M., The high porosity of heat regenerator blocks justifies an approximate theory which can be solved (in Italian), *Termotechnica* **11,** 6, 261–264, June 1957.

3318. Laird, J. P., Design by logic—automatic chemical batching, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-151, 5 pp.

3319. Plank, R., Thermoelectric refrigeration (in German), *Kältetechnik* **10,** 1, 2–10, Jan. 1958.

Author reviews the present state of thermoelectric refrigeration in the fields of research and practical achievement. American, British, French, German and Russian contributions are considered. The use of semiconductors for thermocouples is discussed in detail. The physical properties of the most important semiconductors are mentioned and the influence of impurities is stressed. Several refrigerators and an experimental air-conditioning plant are described.

From author's summary

Combustion

(See also Revs. 2947, 3171, 3252, 3266)

3320. Swett, C. C., Jr., Spark ignition of flowing gases, *NACA Rep.* 1287, 18 pp., 1956.

Author summarizes results of six previously published *NACA Research Memoranda* concerning ignition of flowing gases by long-duration spark discharges, with major emphasis on application to jet-aircraft engines. A simplified theory of spark ignition based on second-order reaction rates and either thermal conduction or eddy diffusion is developed and data are presented confirming theoretical approach.

Experimental data are given showing the effect of gas velocity, temperature, fuel-air ratio, turbulence, and spark discharge parameters on ignition energy requirements, together with some characteristics of spark discharges in flowing gases. Trends in ignition requirements in flowing gases are similar to those in quiescent mixtures except that increases in flow velocity and turbulence increase ignition energy requirements.

F. W. Bowditch, USA

3321. Weinberg, F. J., The thickness of laminar flames in premixed reactants: optical considerations, *Proc. roy. Soc. Lond. (A)* **243,** 1232, 107–118, Dec. 1957.

The problem of measuring flame thickness is discussed in light of the flame's refractive index and the apparent thickness due to optical illusion. Quantitative expressions in terms of burning velocity, flame geometry and the physical properties of flame reactants are derived for the apparent thickness of an idealized luminous zone. The conclusion is reached that measurements of laminar flame thicknesses do not, in general, furnish a true measure of luminous flame thicknesses.

Rays of light are deflected by refractive index radiance occurring in flames.

The optical illusion thickness, which is a consequence of light distortion, is calculated on the basis of simplifying assumptions and is proportional to the burning velocity and the square of the flame length. Numerical calculations suggest that, at very low pressures, flame thickness is rendered negligible by the true thickness of the luminous zone. At barometric pressures, it is in general about equal to true thickness. Flames in a flat flame burner have a thickness which appears to vary approximately as the reciprocal of the burning velocity and for a given burning velocity directly with the presence of an inhibitor. It is concluded that optical means are useful for the measuring of unambiguously defined flame thicknesses. J. H. Davidson, USA

3322. Semikin, I. D., The conformity to rule of the pilot-flame process of gas combustion (in Russian), *Nauch. tr. Dnepropetr. metallurg. in-ta* no. 33, 83-103, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 689.

The distribution of velocity in the different sections, the variation of velocity along the axis, the consumption of gas through the cross section and the diameters of the cross section of the current are determined by means of the equations for the theory of turbulent gas flow evolved by G. N. Abramovich ["Applied Gas Dynamics," Gosteizdat 1953], with values for the experimental coefficient $\alpha = 0.080$ to 0.085. By comparison of the calculated data with the experimental, the influence of the diameter of the jet (caliber of the burner) on the length of the pilot flame is established, as also the calorific value of the fuel, the concentration of O_2 in the air, and the excess of air. For the length of the pilot flame empirical formulas are constructed, taking into account, and not taking into account, the initial velocity of the gas and air, and the temperature of the gas and air. The influence of the constricted nature of the pilot-flame, the angles of incidence, and the distance between the pilot flames are only examined qualitatively. A. B. Reznyakov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3323. Mickelsen, W. R., and Ernstein, N. E., Propagation of a turbulent gas stream, *NACA Rep.* 1286, 26 pp., 1956.

Effective flame speeds for propane-air mixtures were determined in free-flowing turbulent streams. Flames were initiated by spark discharge and allowed to move downstream as free-flame globules. Globule growth was measured by photographic, ionization gap, and photomultiplier-tube methods. Effective turbulent flame speeds so determined were markedly less than those cited from the literature for stabilized flames. F. W. Bowditch, USA

3324. Curtiss, C. F., and Hirschfelder, J. O., Theory of detonations. I, Univ. Wisc. Nav. Res. Lab., (8) no. 15884, 27 pp. Aug. 1957.

Under the assumption of a perfect gas equation of state and special values for the Lewis and Prandtl numbers, the equations governing the steady, plane, reactive flow of a two-component system are reduced to three simultaneous ordinary differential equations. The behavior of the integral curves of this set in the neighborhood of the singular points is investigated as a function of the transport properties of the fluid and the Mach number K at the hot boundary. It is shown that a detonation solution can exist for a continuous range of K, while a deflagration solution can exist for only a single K. This discussion is similar to that given by Friedrichs [U. S. Navy BurOrd. Rep. 79-46, 1946] and reviewer believes that it is valid under considerably more general conditions, such as those proposed by Weyl. [See *Com. pure appl. Math.* no. 2-3, 103-122, 1949; *Amer. math. J.* **73**, 256-274, 1951.]

Numerical results are presented for the integral curves and the spatial dependence of the flow variables, and their variation with Mach number and transport properties is discussed. The solutions presented involve considerable reaction during the initial compression and thus do not have the form of a shock followed by a deflagration. W. E. Drummond, USA

Acoustics

(See Revs. 2995, 3254, 3310)

Soil Mechanics, Seepage

(See Revs. 3025, 3344, 3348, 3356)

Micromeritics

(See also Rev. 3134)

3325. Thomson, J. L., Packed glands for high pressures: An analysis of fundamentals, Instn. mech. Engrs., Prepr., 19 pp., 1958.

A theory of packing glands and stuffing boxes is developed which introduces the packing as a compressible material, the density of which increases with the total pressure on the gland, and the permeability of which decreases with density. The resulting pressure distribution along the packing and the dependence of leakage against outside pressure is well duplicated by measurements. H. A. Einstein, USA

3326. Grunwald, H. H., Glands for the entry of electrical cables into pressure vessels containing or surrounded by conducting liquids, Instn. mech. Engrs., Prepr., 12 pp., 1958.

Drawing on the experience gained with the standard Post Office gland, a disk gland was developed, mainly by theoretical reasoning. This gland has so far satisfied all expectations and, although it has not yet been employed on a working system, it has been in continuous laboratory use over the past two to three years. Large-scale confidence testing has been started.

From author's summary by H. A. Einstein, USA

3327. Lucas, D. H., Certain aspects of the deposition of dust, *J. Inst. Fuel* **30**, 202, 623-627, Nov. 1957.

The practice and theory of the measurement of deposition have been considered. Experiments have been carried out which show that a deposit gage at ground level collects far more dust than a gage 4 ft above the ground. It is concluded that much of this additional catch is dust re-entrained from the ground and is therefore "spurious deposition". Experiments have also shown that a standard gage catches, on average, twice as much dust when its bowl is kept wet as it does normally. The factor varies somewhat from place to place but not sufficiently to invalidate the comparison of average results. It was possible to examine microscopically the dust collected in deposit gages in the rural district around Little Barford Power Station and to establish that only one quarter originated at the power station.

From author's summary

3328. Jogwich, A., Flow of suspensions in a turbulent region (in German), *Forsch. Geb. Ing.-Wes.* **23**, 3, 81-90, Feb. 1957.

A formula for the evaluation of viscosities of laminarly flowing suspensions, first presented by A. Einstein and later completed by V. Vand, is applied to the turbulent flow region. Measurements of the pressure drop and of the velocity distributions in flows of barite suspensions through pipes confirms this viscosity calculation.

Suitable formulas are established to correct the influence due to the sedimentation effect of the solid particles.

From author's summary

3329. Lindner, S., On the separation of solid particles from liquids by hydro-cyclones, *Monthly Tech. Rev.* **2,** 1, 5–12, Jan. 1958. (Translation of *Maschinenbautechnik* **5,** 9, 455–462, 1956.)

Hydro-cyclones are used for separating solid particles from liquids (coagulation), for separating solids according to grain size (classing), and for separating solids or liquids according to their specific weight (cyclones for heavy liquids or washing cyclones). This is a survey of recent publications dealing with the theory, design, and operation of hydro-cyclones, followed by an extension and refinements of the theory, and a plan for further clarifying experiments. Experiments were conducted with a model hydro-cyclone made of glass, with special attention to flow phenomena in the boundary layer, using a paint method. Work was done in cooperation with the Ingenieurtechnische Zentrale of the "Kombinat Otto Grotewohl" at Boehlen, East Germany.

K. J. DeJuhasz, Germany

3330. Rosenthal, G., A critique of particle-size analysis, and a contribution to a practical representation of sieving and sedimentation results (in German), *Keramik. Glas. Email.* **89,** 15, 358–361 + 7 fig. + 10 ref., 1956.

Brief discussion of the Stokes Law, and of influence of particle shape on the sedimentation process. Lowest size limit for validity of Stokes Law was found to be about 0.1 micron. For sedimentation analysis of clays the choice of dispersion medium is important, but yet not fully cleared up. Data on several electrolytes are given, and some required precautions in carrying out the analysis are cited, such as constancy of temperature, avoidance of one-sided heating up of the suspension, and avoidance of shocks and vibrations in the working space. In the separation of particles smaller than 1.0 micron a movable sonde is used for taking a sample, whereby the sinking height is reduced and time of sampling is shortened by one-fourth. The bell-shaped curve for representation of particle spectrum is discussed. The procedures of Andreasen and of Atterberg are discussed.

K. J. DeJuhasz, Germany

3331. Rozenberg, M. D., On the radial displacement of gas-containing petroleum by water (in Russian), *Proc. Acad. Sci. USSR, Appl. Phys. Section* **112,** 1–6, 45–49, Jan.–Feb. 1957. (Translation *Doklady Akad. Nauk SSSR* **112,** 1–6, 603–606. Translated copies obtainable from Consultants Bureau, Inc., New York City).

In previous article by the author and M. M. Glogovski, approximate solution of this problem was presented. This article considers more general problem and proposes an engineering method of calculating the displacement of gassy petroleum by water; however author does not take into account certain real properties of plastic oils and gases, the pressure dependence of the viscosity of petroleum and gas, departure from ideal gas laws, and the change of the volume coefficient of petroleum upon degassing.

J. J. Polivka, USA

3332. Bulygin, V. Ya., Problem of the control, by movement, of the outline of petroliferous strata (in Russian), *Ucben. Zap. Kazansk. gos. un-ta* **115,** 12, 85–97, 1955; *Ref. Zb. Mekb.* no. 1, 1957, Rev. 761.

The possibility is considered of a contraction of outline of an oil-bearing stratum when, in advance, an equation is assigned for its motion. A solution of the problem is put forward dealing with the restoration of the function of pressure in the filtration zone of water and oil, and after that an example of contraction in a circularly arranged set of systems from $(m + 1)$ bores is examined. An example of calculation for a six-bore system is given. Author develops an idea for using a chart of the adduced pressures and permeabilities of the layer when determining and regulating the movement of the contour of the oil-bearing stratum.

V. A. Karpychev

Courtesy Referativnyi Zburnal, USSR

Translation, courtesy Ministry of Supply, England

3333. Saikin, S. F., Determining the location of a water-petroleum contact in an oil-bearing stratum in a dynamic condition (in Russian), *Ucben. Zap. Kazansk. gos. un-ta* **115,** 12, 99–110, 1955; *Ref. Zb. Mekb.* no. 1, 1957, Rev. 762.

Emanating from the fact that in the process of displacement of petroleum by water the distribution of pressure curve shows a break at the "water-petroleum" contact surface [V. N. Shchelkachëv, B. B. Lapuk, "Subterranean hydraulics," Gostoptekhnizdat, 1949], author approximates the curves of depression with 2–3-parametric curves, upon which the parameters are determined with the help of technical data. With the determination of the break in the distribution of pressure curve, the location of the water-petroleum contact surface in the stratum is also determined.

V. A. Karpychev

Courtesy Referativnyi Zburnal, USSR

Translation, courtesy Ministry of Supply, England

3334. Saikin, S. F., Hydromechanical methods of tracing the progression of a water-petroleum contact surface in an oil-bearing stratum (in Russian), *Ucben. Zap. Kazansk. gos. un-ta* **115,** 12, 130–132, 1955; *Ref. Zb. Mekb.* no. 1, 1957, Rev. 763.

Two ways are examined for an approximate determination of the water-petroleum contact surface in a given section of the oil-bearing layer. The first way is based on the use of the known condition of breaking the lines of flow on the boundary of the separation of the liquids (water and petroleum); it is recommended that the determination of the point of water-petroleum contact in the given section should be carried out by constructing the corresponding piezometric curve, utilizing also the isobar chart. The detection of the break of the piezometrical line will determine the point of surface contact of the water-petroleum mixture in a given section of the stratum. The second way is based on the use of some approximate elementary relations between joint inflows of two incompressible liquids, flowing toward the bores.

V. P. Pilatovskii

Courtesy Referativnyi Zburnal, USSR

Translation, courtesy Ministry of Supply, England

3335. Shchelkachev, V. N., Arrangement and investigation of the problem of some regular water incursions into oil wells under the simplest of conditions (in Russian), *Trudi Mosk. neft. in-ta* no. 14, 184–196, 1955; *Ref. Zb. Mekb.* no. 1, 1957, Rev. 764.

The possibility is substantiated of investigating a flow, as on a plane, in the oil stratum, interrupted in stratification by a number of poorly permeable seams. For such a stratum the problem is put forward of determining the water content of the oil-well with the passing of time and taking account of the original contour of the oil-bearing strata. One special problem gone into was that of a single hydrodynamic well, with the original contour for the oil-bearing stratum arranged star-shaped with reference to the well. The difference in viscosity of the petroleum and water is not taken into account; the liquid and the rock stratum are incompressible and homogeneous. The reverse problem is also put forward, the determination of the original contour of the oil-bearing stratum corresponding to the given law for the water-bearing supply. Examples of the calculations are given.

V. L. Danilov

Courtesy Referativnyi Zburnal, USSR

Translation, courtesy Ministry of Supply, England

3336. Dzhalilov, K. N., Theoretical investigation of the process of water incursion into an oil well under the simplest conditions (in Russian), *Trudi Mosk. neft. in-ta*, no. 14, 196–202, 1955; *Ref. Zb. Mekh.* no. 1, 1957, Rev. 765.

A study is made of the water incursion of a single working well with a plane-radial flow under conditions of a water-pressure system, without taking into account the difference in the viscosities of petroleum and water. Author determines the variation in petroleum content in the liquid being extracted in the course of time and various outlines of the original contour of the petroleum-bearing stratum and the distances of that contour from the well [see preceding review]. First of all the rectilinear and circular contours are examined. Tables and curves are produced for the water incursion. A deduction is made of the striving on the part of the petroleum in the general yield of the well to reach the boundary value of 0.5 during the original rectilinear contour. The deduction is transposed to the case of a contour of arbitrary form. In the supplement, an analytical expression is given for the relation of the yield of the whole of the liquid in the examined example.

V. L. Danilov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3337. Baranovskaya, N. N., Hydrodynamic investigation of the simplest cases of the shifting of the contour of the oil-bearing stratum and water incursion into the wells (in Russian), *Trudi Mosk. neft. in-ta*, no. 14, 203–212, 1955; *Ref. Zb. Mekh.* no. 1, 1957, Rev. 766.

An investigation is made of the shifting of the contour of the oil-bearing stratum with subsequent water incursion of the wells being worked in the cases (1) of rectilinear system of staggered working and pressure-actuated wells and (2) of a rectilinear system of working wells. The stratum is taken to be homogeneous in regard to permeability, porosity, and capacity; the movement of the homogeneous, incompressible liquid is taken to be plane, steady, conforming to the linear principle of filtration; the wells are taken to be equal in yield for springs and drains; the system a single liquid. The time of the inrush of water into the well is determined and the process of water incursion is studied according to V. N. Shchelkachev's method [Rev. 3335 above]. A graph is shown of the movement of the fractions along the principal lines of the flow and also a graph of the water incursion into a group of wells. In the supplement, parametric equations of the water-petroleum contact surface are given, and also the analytical dependence between the angle of water incursion and time. V. L. Danilov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3338. Pekhovich, A. I., Evaluation of the water permeability of earth-ice screens in the process of their formation (in Russian), *Izv. Vses. n.-i. in-ta gidrotekhn.* **54**, 208–213, 1955; *Ref. Zb. Mekh.* no. 1, 1957, Rev. 769.

To create water-impermeable dams by means of artificial freezing, freezing columns are laid at determined distances in the soil, round which, to start with, separate earth-ice cylinders are formed, coalescing ultimately into a single water-impermeable body. To determine a rational system of refrigeration and a system of water outflow from the basin it is essential to know the value $\nu(t) = Q_t/Q_0$ where Q_0 is the discharge of the filterable flow when the earth-ice cylinders are present, while t = time. After the complete coalescence of the earth-ice cylinders $\nu(t)$ is a constant. The author puts forward and solves approximately, by means of N. N. Pavlovskii's method of fragments, the following problem.

A dam of rectangular transverse section with a width H is postulated. The earth-ice cylinders of radius R are placed in the dam in one row at equal distances S from each other. The dam is situated on a water-permeable foundation. The water filtration takes place by means of the action of constant difference in pressures between the side faces of the dam. Filtration round the shoulder of the dam is excluded. The soil of the dam is homogeneous. The rate of growth of the earth-ice cylinders is very small (not more than 6 cm in 24 hours), which permits the movement of the filterable flow to be taken as steady. The velocity of water movement is everywhere found to be within the limits of applicability of d'Arcy's principle. On these assumptions the following approximate formula for the value of ν is obtained

$$\nu = \frac{\chi}{\chi + (1-\epsilon^2)^{-\frac{1}{2}}(\arcsin\epsilon + \frac{1}{2}\pi) - \epsilon - \frac{1}{2}\pi}$$

$$(0 \leqslant \nu \leqslant 1)$$

where

$$\chi = H/S,\ \epsilon = 2R/S,\ R = R(t),\ S = S(t).$$

Comparison of the results obtained by this formula with the results obtained by the EGDA method gave a divergence of the order of ± 5%. Following an analogous course, a problem was solved in the more general case when there are n parallel rows of cylinders. However, further analysis showed that from the point of view of counterfiltration effect it is expedient to arrange the whole of the available earth-ice cylinders in a single row.

P. F. Fil'chakov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3339. Kotyakhov, F. I., Filtration systems through a porous medium (in Russian), *Trudi Akad. neft. prom-sti* no. 1, 278–290, 1954; *Ref. Zb. Mekh.* no. 1, 1957, Rev. 770.

In the work by F. I. Kotyakhov, B. F. Remnev and N. P. Butorin "Core analysis of petroleum formations" [Gostoptekhnizdat, 1948] the following expression was proposed for Reynolds parameter:

$$R = \frac{4v_\phi\sqrt{2K}}{\nu m\sqrt{m}} \quad [8]$$

where k is the permeability coefficient, m the porosity, v_ϕ the rate of filtration. From this conception of Reynolds parameter R and Poiseuille's principle, author obtains an expression for the resistance coefficient

$$\lambda = \frac{2m\sqrt{km}\,\Delta p}{Lv_\phi{}^2\rho} \quad [15]$$

Relevant recalculations were made of the experimental data of Feucher, L'yuis and Burns ["Physical Tests of the rocks in petroleum and natural gas strata," INT, (105), Azneftеizdat, 1934] for the construction of curves $\lambda = f(R)$.

Up to the value $R = 0.3$ complete agreement of the experimental data with d'Arcy's principle is observed. The author explains the small number of off-curve points as due to the difficulty of accurate readings on Feucher's curve. The breakdown of the linear law of filtration is due, according to author, to the narrow zone of oscillation of the value of the number R. Issuing from expression [8] the critical velocity of filtration is

$$v_{cr} = \frac{0.3\mu m\sqrt{m}}{4\rho\sqrt{2k}} = \frac{0.053\mu m\sqrt{m}}{\rho\sqrt{k}} \quad [19]$$

If the empirical function $\lambda(R)$ given by the author for values of R from 0.3 to 0.5 is to be made use of, then the critical pressure at which the breakdown of d'Arcy's principle takes place is

$$\Delta P_{cr} = \frac{0.053\mu^2 m\sqrt{m}\,L}{k\sqrt{k}\,\rho} \quad [23]$$

From checking the examples author is of the opinion that the well yields can be calculated according to the linear law of filtration. A. A. Sabaneev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3340. Aleskerov, S. A., and Makhmudov, Yu. A., Problem of building electric models of a petroleum-bearing stratum (in Russian), *Izv. Akad. Nauk AzSSR* no. 8, 3–10, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 773.

A schematic description is given of the construction of an electric model EM-8 for the solution of irregular processes for the filtration of petroleum in conditions of stratification, depicted in differential equations with particular derivatives of the Fourier type. An outline scheme of the model is presented; it consists of (1) a network of ohmic resistances, with capacitors connected to its nodes, (2) a period indicator unit with scheduled time divisor, (3) units of connected wells, (4) a unit of assigned original conditions, (5) unit of electronic measurement devices, (6) unit of discharge capacity of the network, (7) a power unit.

To simplify the techniques of measurement and to increase the accuracy of measurement, the modelling process, with the help of the period indicator, is repeatedly reiterated. In the EM-8 connection, the setting of the starting and boundary conditions, the measurement, and also the preparation of the network, for repeated connection, is carried out with the help of special schemes with electronic valves, which replaced the earlier used, (and which did not justify their use in practice), rotating, electromechanical relay-contact appliances. This enables the time r_1, modelling the period of working the petroleum bed, to be taken so much smaller that the condenser capacity, joined to the network terminals, should not be too great and should not give rise to an increase in the profile dimensions of the model.

In the electric model EM-8, r_1 varies from 0.1 to 0.002 sec. The electric oscillations from the period indicator are passed on to the scheduled time divisor, where time r_1 is divided in 100 parts, so that the process can be followed in the current of any of these hundred intervals of time r_1.

In the electronic measurement devices, provision is made for special accessories for photographing the function being measured, $u = f(x, y, t)$, in the nodal points of the network of the model. With this in view there is an arrangement of two parallel built-in cathode ray tubes: one—the main one—of large diameter, or type 13L036; the other—supplementary—with small diameter, of type 8L029. The photographing of $u = f(x, y, t)$ is carried out from the screen of the main tube, during which investigations are made with the supplementary tube. It is also possible to make a visual examination and the measurement of $u = f(x, y, t)$ in any nodal point of the network. P. F. Fil'chakov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3341. Surovtsev, B. P., Investigation of the problem of filtration in a planned hydro-electric station (in Russian), *Trudi Tashkentsk. in-ta inzh. irrigatsii i mekhanizatsii*, S. Kh. no. 1, 141–150, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 777.

An investigation was made, with the help of electro-hydrodynamic analogies, of the filtration pressure and outflow velocities for seven different types of dam aprons of a hydrostation built on a permeable foundation in complex geological conditions. The investigations were made in an electrolytic bath and on a plane model, shaped from paraffin wax impregnated cardboard, with the utilization of an electro-conducting medium made from fine quartz sand moistened with a solution of cooking salt. As a result of the investigations carried out, a more rational underground profile for a hydrotechnical installation was found from the data of concrete conditions. In the same apparatus a direct curve was established for the static pressure on the supporting walls.

P. F. Fil'chakov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3342. Kuliev, A. M., and Babalyan, G. A., Study of the process of displacement of water by petroleum (in Russian), *Trudi Neft. ekspeditsii Akad. Nauk AzSSR* **2**, 91–96, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 779.

Results are given of experimental investigations on the displacement of water by kerosene from a sand model of the stratum, of various lengths, permeabilities and angles of slope of the model to the horizontal. The pressure gradients were such that the residual water saturation did not decrease practically when the gradient increased. Authors deduced that in these conditions the effect of gravity is not shown in the magnitude of the residual water saturation. Relations were obtained between the residual water saturation, length of the model, and its permeability. Making use of these relations, authors propose to introduce into the experimental data on short models corrections for applying the data to conditions met with in nature. V. L. Danilov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3343. Komarovskii, A. A., and Strel'tsov, V. V., Hydrodynamics of the process of dissolving salt in an immovable layer (in Russian), *Trudi Novocherkas. politekhn. in-ta* **31**, 13–24, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 793.

The experimental investigation is described of the hydrodynamics of the process of solution, in a model, of an immovable layer, made up of undissolved cylindrical particles of different dimensions, showing similarity to the geometrical form. The apparatus is described and the results of the experiments in the transitional region of Reynolds criteria are discussed. The authors deduce that for the turbulent zone the experimental results with an accuracy of 14–17% correspond to the calculation of the hydraulic resistance of the layer relative to the change of weight of the particles. The same method of calculation for the laminar zone gives the worst result, in consequence of inaccuracy in measuring small drops of pressure. The semi-empirical formulas obtained are proposed for use in calculating the changes in resistance in the salt layer when being dissolved, or in calculating the changes in resistance when semidissolved bodies of one dimension are substituted by similar bodies of another dimension. In both cases the considerations of geometrical similarity should be taken into account. A. V. Lykov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3344. Terletskaya, M. N., Experimental investigation of seepage round the ends of a dam on a large-scale model in an earthen trough (in Russian), *Trudi Gruz. n.-i. in-ta gidrotekhn. i melior.* **3**, 16, 233–247, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 754.

A method is described and results given of experiments of the filtration round the left shoulder of an earth dam, with a height of 72 m, a bottom length of ~ 500 m, width of the soil (base) up to 500 m, with active pressure of 67 m. The investigations were carried out on a large-scale model in an earth trough. The object was to determine the contour of the thinning out of the filtration stream in the "lower water," the gradients and filtration discharge on a portion of the left bank, built up of a massive thickness of pebbles with a sand filler and argillaceous soil (filtration coefficient $k = 5 \times 10^{-4}$ cm/sec); below the pebbles a layer of tertiary conglomerate was laid down ($k = 4 \times 10^{-5}$ cm/sec); above them—a discontinuous (with "windows") layer of clay ($k = 4 \times 10^{-4} - 4 \times 10^{-7}$ cm/sec). The scale of the model was 1 : 400. Eight experiments in all were carried out on the model; of this number four

experiments were made with a "cemented curtain" 50 to 250 m in length. It was established that the pressure gradient at the outlet in the "lower water" did not exceed 0.056, which, according to author's data, is six times less than the critical at which it is possible for drenching (suffusion) to take place in similar soil strata. The water discharge by filtration (seepage) round the left shoulder of the dam was found to be 23.5 – 25.2 *l*/sec.

F. M. Bochever
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3345. **Miller, E. V., and Klassen, V. I., Calculation of the velocity of the vertical movement of mineral granules in a liquid** (in Russian), *Gorniyi Zh.* no. 5, 52–60, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 730.

An investigation is described of the velocity of a settled movement of mineral particles in water. The problem is solved, both for the case of the movement of separate granules and for the case of the simultaneous movement of a great number of granules; at the same time two cases are gone into of the flow around the granule, taking into consideration, and not taking into consideration, the resistance in the boundary layer of the granule. Formulas are submitted for the speed of settling of the mineral granules in the still liquid, which, in the authors' view, are well confirmed by the experimental data. N. A. Mikhailova
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3346. **Bogoroditskii, K. F., Movement of natural gas-impregnated waters in interstices** (in Russian), *Trudl Labor. gidro-geol. problem, Akad. Nauk SSSR* **12**, 71–88, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 719.

An equation is proposed for the movement of gas-impregnated waters in vertical interstices, in the compilation of which a series of assumptions and hypotheses are introduced (the relative velocity of the gas is taken to be zero and the law of resistance, when there is movement in the gas-liquid mixtures, is hypothetically formulated); author's method for calculating the movement of gas-liquid mixtures, in effect, does not exhibit any great practical value. A number of conceptions of a general character are advanced to show the reciprocal work of the interstices and of the regime of the water-carrying stratum. V. A. Arkhangel'skii
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3347. **Ivyanskii, G. V., Systems of movement and the magnitude of resistance pipes to the movement of dispersions of materials used in building** (in Russian), *Stroit. prom-st.* no. 3, 25–29, 1956; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 725.

Some deductions are given, made known by various investigators, examining the movement of structural solutions and other dispersion systems. The experimental work carried out to ascertain the character of the movement of the following constructional solutions is briefly stated: lime whitewash 1 : 3, compound 1 : 1 : 6 and cement 1 : 3. The results establish that, with the regular movement created by the vibrating mixing pump, the dispersion in the pipes moves at a uniform speed along the whole section of the pipe, with the exception of a thin part next to its wall. According to the experimental data, the thickness of this part varied within the limits of 3–4mm for pipes of 75-mm diam and of 1–3 mm for pipes of 50 to 38-mm diam. When the movement is periodically progressive due to the plunger pump, the dispersion in the pipes is carried along at different speeds in tube section. The possibility is established, when there is even flow of the dispersed materials with velocities not exceeding 0.5m/sec, of applying the known function: $\tau = \eta(dv/dy) + \tau_0$, where τ is pressure of internal friction in kg/m^2, η dynamic coefficient of internal friction in kg.sec/m^2; dv/dy gradient of velocity in sec^{-1}; τ_0 boundary pressure of slip in kg/m^2, v velocity in m/sec. On the basis of the experiments carried out, propositions are put forward for determining the maximum losses of pressure on one running meter of rectilinear horizontal metallic pipes. A. N. Klimentov
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3348. **Nel'son-Skornyakov, F. B., Filtration through a drained earthen layer with a shield impenetrable by water and with the front part of the spillway having no spurs or channel** (in Russian), *Trudl Mosk. in-ta inzh. zh.-d. transp.* no. 80/1, 340–356, 1955; *Ref. Zh. Mekh.* no. 12, 1956, Rev. 8399.

An examination is made of an approximate solution of the title problem. With the assistance of a method developed earlier [F. B. Nel'son-Skornyakov, "Filtration through a homogeneous medium," Sovetskaya nauka, 1949], the following limited cases were scrutinized: When the outline of the spillway and shield in the region of N. E. Zhukovski's function *G* represents some curve of a parabolic type; (2) when the outline of the spillway and shield in the region of *G* represents a length of an inclined straight line.

With the accepted outline of the boundary of the region of movement of subsurface water in *G*, the boundary of the original region is reestablished; this is found to be near the assigned outline of the shield and spillway and the line of the upper water. The solution is obtained in a closed form in elémentary functions, when determinations are made of all the elements of the filter stream, including as well the position of the curve of depression. An analysis of the results obtained show that the majority of spillways and shields met with in practice is included among the limited outlines of shields and spillways referred to above.

With values $B/H = \geqslant 5$, where B is the horizontal projection of spillway and shield (in region *G*), H the active support, customarily met with in practice, the computing formulas are substantially simplified. An example is examined, in which the error, when the maximum ordinate of the depression curve is determined, does not exceed 4%. P. F. Fil'chakov
Courtesy Referativny Zhurnal, USSR
Translation, courtesy Ministry of Supply England

3349. **Dzhalilov, K. N., Determination of the peculairities of irrigation of a well in relation to the time, taking into account the difference in the viscosities of petroleum and water** (in Russian), *Izv. Akad. Nauk AzSSR* no. 9, 15–25, 1955; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6754.

The problem raised is examined approximately for two cases: namely when the original petroleum-bearing contour is (1) rectilinear, and (2) circular. Author arrives at the following conclusions: (1) Irrigation of the well occurs more intensively at first after eruption of the water into the well, then the tempo of irrigation becomes slower. For a closed contour the intensity of irrigation increases before complete irrigation of the well.

(2) The greater the relative viscosity of the petroleum, the later the irrigation begins and the more intensively it occurs.

N. N. Baranovskaya
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3350. **Salekhov, G. S., Application of a method of minimum error to the solution of the problems of control of the motion of a petroleum-bearing contour** (in Russian), *Izv. Kazansk. fil. Akad. Nauk SSSR, Ser. fiz.-matem. i tekhn. nauk.* no. 8, 3–15, 1955; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6756.

For solution of the problem of control by displacement of the petroleum-bearing contour, which was studied earlier by the author [*Izv. Kazansk. fil. AN SSSR, ser. fiz.-matem. tekhn.* no. 5 3–15; *Ref. Zh. Mekh.* 1956, Rev. 5308], it is suggested that the general method of minimum error with the standard of least mean quadratic deviation should be used. For the sake of the general aspect of

the method, the concept of the Stilties integral is used both for the case of "continuous" and "discrete" (according to points) setting of the initial petroleum-bearing contour. The minimum condition of error in the approximation of the known condition for the bed pressure on the mobile boundary of demarcation of the liquids is insured as a result of variation of the coordinates and yield of the wells. In this the problem of the evaluation of the minimum error between the required law of displacement of the demarcation boundary of the liquids and its actual movement is not discussed. The suitability of the method is examined for cases only continuous or only discrete data relative to the motion of the petroleum-bearing contour. Certain particular results which were obtained by the general method are compared with the results obtained earlier.

V. P. Pilatovskii
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3351. Danilov, V. L., Control of the displacement of the petroleum-bearing contour taking into account the difference in viscosity of petroleum and water (in Russian), *Izv. Kazansk. fil. Akad. Nauk SSSR, Ser. fiz.-matem. i tekhn. nauk* no. 8, 30-54, 1955; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6758.

The problem is posed and solved of the control of the displacement of the *G* boundary of demarcation of incompressible liquids in a homogeneous horizontal bed of constant force. The difference in the viscosity of petroleum is considered; it is assumed that the filtration in each of the regions occurs according to a linear law. The problem is examined for the case when the position of the wells is fixed, and the yields of the wells are determined at which the given displacement of the boundary of demarcation of the liquids is possible, although only approximately.

Using the known boundary conditions of the *G* boundary, author reduces the solution of the problem to the solution of a certain system of Fredholm linear equations of the second type. With the aid of the solution of the system obtained, the pressure distribution in both the water and petroleum zones is expressed. For a fixed arrangement of the wells, the pressure distribution in each of the zones is a linear function of the well yield. This circumstance simplifies the system of corresponding equations.

The known boundary condition on the mobile boundary of demarcation of the liquids is approximately satisfied by the known distribution of pressure (for example, by the method of minimum quadratic error). An examination is made of certain methods of approximate satisfaction of this condition at the *G* boundary. The possibility is discussed of using G. G. Tumashev's method [*Ref. Zh. Mekh.* 1954, Rev. 4142] for solving the problem set; this method gives certain simplifications, since the necessity of previous solution of the integral equations disappears. An example of the solution of the problem is examined.

V. P. Pilatovskii
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3352. Ivanov, N. F., Graphical method of analysis for following the petroleum-bearing contour (in Russian), *Izv. Kazansk. fil. Akad. Nauk SSSR, Ser. fiz.-matem. i. tekhn. nauk no.* 8, 72-82, 1955; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6759.

An examination of the graphical method of analysis for solving the title problem, for the case of a infinite homogeneous isotropic horizontal bed saturated with a noncompressible liquid. By the petroleum-bearing contour is understood a certain single-bond contour of the particles recorded; for determination of the law of motion of this contour it is suggested that a family of equipotential lines be constructed jointly with the family of lines of the current. The plane surface in which the displacement of the contour is studied breaks down into separate square fields; for the centers of these fields, values of the functions

$$A = \sum_j Q_j \ln \rho_j, \qquad B = \sum_j Q_j \varphi_j$$

are calculated.

With the aid of a system of numbers A, B, the linear interpolation of the velocity potential and the flow function is effected. On the basis of completely obvious relationships, "synchronous" contours of the initially noted particles in the filtration field are plotted. Two methods of this plotting are discussed. The first method is based on the graphical integration of the equation of motion of the particular particle along its line of flow, the second on the use of the evident relationship between the flow function and the total yield of the system of wells.

V. P. Pilalovskii
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3353. Danilov, V. L., Determination of the pressure in beds having variable porosity and force (in Russian), *Izv. Kazansk. fil. Akad. Nauk SSSR, Ser. fiz.-matem. i tekhn. nauk* no. 8, 129-136, 1955; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6762.

Examination of the problem of pressure distribution in a seam having a variable power $h(x, y)$ and a variable porosity $k(x, y)$ when there is one well. An incompressible liquid filters in a bed in accordance with the Darcy law. The pressure is taken in the form

$$p(x,y,t) = f(x,y,t) + \frac{Q(t)\,\mu}{2\pi\sigma(x_0y_0)} \ln \frac{1}{\sqrt{(x-x_0)^2 + (y-y_0)^2}}$$

where (x_0, y_0) are the coordinates of the well having a yield of $Q(t)$. In observing the usual boundary conditions in the relationship $p(x,y,t)$ the function $f(x,y,t)$ is determined from the equation

$$\Delta p = (1/\sigma)(\nabla\sigma, \nabla p), \ \sigma(x, y) = h(x, y)\, k(x, y)$$

This equation is reduced to a form suitable for finding $f(x,y,t)$. For solution of the given marginal problem it is suggested that the Pikar method of successive approximations be used. The problem is illustrated by an example.

V. P. Pilatovskii
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3354. Svirskii, I. V., Problem of the forced exploitation of petroleum wells (in Russian), *Izv. Kazansk. fil. Akad. Nauk SSSR, Ser. fiz.-matem. i tekhn. nauk* no. 8, 150-153, 1955; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6763.

It is shown that in a nonhomogeneous bed which is everywhere isotropic and is of infinite force, with the nonlinear law of filtration of an elastic liquid, waterless exploitation of any number of wells gives the greatest total yield when the face pressure is reduced to the critical value, at which separation of gas from the petroleum begins. This problem was examined earlier for a particular case [*Ref. Zh. Mekh.* 1953, Rev. 243]. The equation of nonseparation of the flow is used for proof. An essential factor in this proof is the assumption that the components of density of the mass flow of petroleum (i.e. of the weight of petroleum passing in a second through unit areas perpendicular to the coordinate axes) represent functions only of the pressure, pressure gradient, and coordinates.

V. P. Pilatovskii
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3355. Gazlev, G. N., Gas-dynamic calculations in planning the processing of deposits of natural gases (in Russian), *Tr. Neft.*

ekspeditsii Akad. Nauk AzSSR **2,** 17-54, 1955; *Ref. Zb. Mekh.* no. 10, 1956, Rev. 6765.

Examination of the calculations of purely gas and water-pressure conditions of working a seam. Author considers that disregard of the coefficient of supercompressibility of a gas even at bed pressures of 100 atm, which are comparatively low for gas deposits, may introduce errors into the calculation of the gas reserve of up to 15%.

An explanation is given of a method of calculating variations in time of the coefficients of utilization of the gas reserve and the number of wells necessary to insure the given total yield from the deposit in relation to the variation in the bed pressure. The calculation is based on the assumption that the rate of filtration on the face of the well during the whole operation period of the deposit is constant. The calculation of the variation with time of the reduced yield of the individual well, which depends on the pressure at the face, is not made clear by the explanation.

It is recommended that calculation of the pressure losses in the shaft of the well be made from the Weimaut formula, taking into account the losses in overcoming the weight of a gas column.

Recommendations are given regarding the investigation of exploratory gas wells to obtain the initial data on the seam and the well which are necessary for planning (optimum output of the well, relationship of output to the fall of pressure in the bed, bed pressure, mean porosity of the collector in the zone of the well near the face, etc.). A. L. Khein

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3356. Maslov, N. N., The problem of the dynamic stability of sand saturated with water (in Russian), 13-ya nauch. konferentsiya Leningr. inzh.-stroit. in-ta, Leningrad, 1955, 42-43; *Ref. Zb. Mekh.* 1956, Rev. 5328.

This report describes tests performed in 1954. The object of the tests was the further verification of the basic assumptions and the development of "the filtration theory of dynamic stability of water-saturated sand" proposed by the author.

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

Geophysics, Meteorology, Oceanography

(See also Revs. 3002, 3087, 3225, 3310, 3312)

Book—3357. Lettau, H. H., and Davidson, B., Exploring the atmosphere's first mile. Vol. I: Instrumentation and data evaluation, New York, Pergamon Press, Inc., 1957, xiv + 376 pp. $15.00.

These volumes deal with the experiments in Nebraska designed to study the profiles of wind, temperature, and other meteorological quantities in the atmospheric boundary layer. This first volume concerns instrumentation and data evaluation. Descriptions and schematics appear with many of the presentations of specialized instruments. Almost all are original concepts.

In all, 65 scientific papers by outstanding scientists from universities and government agencies discuss soil physics, interface measurements, most profile data, fluctuation quantities, and free air observations. The last paper contains data evaluations.

This is an excellent reference book on instrumentation relative to the subject. The papers are to the point and are well written.
C. J. DeZeih, USA

3358. Urupov, A. K., and Ryabinkin, L. A., Multiply-reflected, refracted waves as a quality-reducing factor in the seismic materials of the Russian plateau (in Russian), *Tr. Mosk. neft. in-ta* no. 12, 80-91, 1953; *Ref. Zb. Mekh.* no. 10, 1956, Rev. 6912.

Authors consider the fundamental cause of disturbances in seismic observations by the method of reflected waves in the Russian Plateau to be the presence of simultaneously-arriving waves from the intermediate, refractively reflecting boundaries. The investigation correlates the theoretical hodographs of waves, singly or multiply, reflectively refracted at an inclined boundary with the experimentally obtained hodographs of waves originating at the meso-palaeozoic boundary, segregated by the method of regularly directional reception. It is demonstrated that the kinematic and dynamic properties of such waves enable them to be regarded as one of the principal causes of the distortion of seismic records of waves reflected from the surface of a foundation. Recommendations are made for counteracting the influence of such wave disturbances.

It should be noted that the results of the analysis of multiple reflectively-refractive waves partially correspond to those already published in the work of I. S. Berzon and A. M. Epinatyeva [*Izv. Akad. Nauk SSR, Ser. geofiz.* no. 4, 1953], and N. N. Puzyreva [op. cit. no. 2, 1955]. L. P. Zaitsev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

3359. Bartholomeusz, E. F., The reflexion of long waves at a step, *Proc. Camb. phil. Soc.* **54,** 1, 106-118, Jan. 1958.

Special case of "long-wave theory" in which the waves travel along a canal with a vertical step is treated rigorously by the linearized theory of surface waves. The first attempt to solve this problem was made by Lamb. Author obtains a singular Fredholm integral equation of the first kind for the horizontal velocity above the canal step and converts this equation into a regular equation of the second kind with a kernel which tends to zero as the wave length tends to infinity. To achieve this, formal limit of infinity is taken first in the integral equation of the first kind, which corresponds to a fluid motion between rigid boundaries permitting explicit solution by a conformal transformation. The inverse operator obtained for the infinite wave length is then applied to the original equation for finite wave length. Equation of the second kind results which has a kernel tending to zero as the wave length tends to infinity and which is solvable by iteration for large wave length. Although Lamb's method fails to describe the details of the motion, his predicted reflection coefficient appears as a first approximation.

References are made to G. Kreisel, T. H. Havelock, E. Schmidt, E. T. Whittaker and G. N. Watson, E. C. Titschmarsh, and N. I. Muskhelishvili. J. J. Polivka, USA

3360. Fitzpatrick, P. M., Sea bottom pressure fields produced by yawed vessels, *Proc. Amer. Soc. civ. Engrs.* **84,** EM 1 (*J. engng. Mech.*), Pap. 1496, 13 pp., Jan. 1958.

An attempt has been made to set forth a procedure which may be employed to obtain a rough approximation of the sea-bottom pressure distributions produced in the neighborhood of the upstream hull line by a surface vessel yawed more than 20°. The vessel is considered to move at low speed in calm sea of moderate depth. To this end a treatment of the flow pattern around an ellipsoid model in an infinite nonviscous fluid half-space is given. A brief derivation of the most important formulas for the velocity and pressure distributions produced by the ellipsoid on the plane boundary is presented. The mathematical complexities involved if one attempts to determine an analytical expression for the curves of equipressure change are pointed out and an alternative procedure for obtaining these curves is described. An application of the theory has been made to a special case. The results of certain calculations made in this regard have been presented to illustrate the principal features of the pressure distributions which may be expected.

From author's summary by E. Steneroth, Sweden

3361. Stelson, T. E., and Murtha, J. P., The virtual mass of cylindrical bodies at a free surface, Proc. Fifth Midwestern Conf. Fluid Mech., Univ. of Michigan, Apr. 1957. 330–336.

3362. Defant, A., Tidal waves and tides of the water (in German), Encyclopedia of Physics, Vol. 48, Geophysics 2, Springer-Verlag, 1957. 846–928.

In his encyclopedic article, author gives a comprehensive survey on the problems of tidal waves in channels of constant or variable cross section and on different forms of stationary oscillations in closed or semi-open water basins. Also the different forms of progressive and internal waves are considered, including the reflection of Kelvin waves in a rotating rectangular basin and regarding cellular waves in a medium with decreasing density.

After a resumé of Laplace's dynamic theory of tides, the tidal motions in finite oceans are considered and characterized by their harmonic constants. The influence of friction and earth rotation on the tidal flows, especially in shallow marginal seas, is explained; an extensive bibliography is given for special investigations on tidal motions in most bordering seas over the whole earth, with detailed attention to the Adriatic.

Concluding remarks relate to the tidal motions of the solid earth crust and to the connection of the energy dissipation on the decrease of the rotation speed of the earth. It is shown that the main contribution is delivered by the shallow seas and not by the free ocean. W. Wuest, Germany

3363. Hanzawa, M., Preliminary report on a close relationship between surface water temperatures at the two separated ocean stations Papa and Tango, *Oceanogr. Mag.* **8,** 2, 157–160, Dec. 1956.

3364. Bogdanova, N. P., The prediction of ground surface temperatures in the presence of fog (in Russian), *Trudi gl. Geofiz. Observ.* no. 46, 87–89, 1955; *Ref. Zb. Mekb.* no. 11, 1956, Rev. 7595.

A formula is obtained analytically for the prognastic calculation of ground surface temperatures in the presence of fog. The derivation of this formula is based on the expressions applicable to prognostication of ground surface temperatures according to the distribution of ground temperatures in depth at the initial instant and the temperature increment due to heat losses from the ground surface [D. L. Leichtmann, *Trudi gl. Geofiz. Observ.* no. 22, 1950; F. N. Schaechter and G. H. Zeiten, *Trudi gl. Geofiz. Observ.* no. 27, 1951], as well as the curve of variation of the effective radiation on the appearance of fog. The heat loss at the instant of sunset is regarded as approximately equal to the amount of effective radiation. The example adduced shows that, on the appearance of fog, the nocturnal temperature drop at the surface of the ground is somewhat mitigated. G. V. Dmitrieva

Courtesy Referativnyi Zburnal, USSR

Translation, courtesy Ministry of Supply, England

3365. Eliassen, A., and Kleinschmidt, E., Dynamic meteorology, Encyclopedia of Physics, Vol. 48, Geophysics 2, Springer-Verlag, 1957, 154 pp.

This work is the best survey of dynamic meteorology to be published since World War II, the authors being also important original contributors to the field. In 154 pages they have managed to include an astonishing amount of important material, in a treatment more than usually intelligible to non-specialists. The methods used disclose the similarities and differences between meteorology and other hydrodynamical sciences; the emphasis is always physical, and the pages have a decent balance of test and equations.

The five chapters cover, respectively, the basic equations; small perturbations of adiabatic, inviscid flow; nonlinear models of cyclonic-scale motions, suitable for numerical intergration; the dynamics of cyclones and the jet stream; and the general circulation. Welcome to textbook literature are such topics as "balanced" flow (i. e. with small horizontal divergence), energy exchange between eddies, the mountain wave, variational methods in deriving stability criteria, and others which have been followed through the periodical literature only by specialists.

Certain topics are treated only briefly or omitted altogether: statics and thermodynamics; small-scale turbulence; convection and thermal circulations; atmospheric tides. The last of these is the subject of a separate article in the same volume of the *Handbucb*; the others are covered more or less well in existing texts.

A glance at the references shows that the work of many investigators in the field is not mentioned. The authors have presented what they consider to be the main line of research; the reviewer agrees with their judgment and affirms their success in what they have attempted. M. Wurtele, USA

3366. Lauwerier, H. A., The influence of a homogeneous wind upon an infinitely wide North Sea, *Matb. Centrum, Amsterdam Rap.* *TW*41, 31 pp., Nov. 1957.

Assuming the mathematical model of a semi-infinitely wide sea of a constant depth, with straight line coast, the elevation of the sea level above the undisturbed level is computed as the solution for the linearized equations of motion in hydrodynamics. After Laplace transformation is applied, a solution of general type is obtained. Elevation at the coast is computed for four cases, i. e., (1) free motions as defined by the author, (2) periodic winds, (3) constant winds starting at the initial time, and (4) periodic winds starting at the initial time. This paper is *only* a first step toward the solution of the influence of an arbitary wind field upon the elevation of the rectangular North Sea model.

H. Arakawa, Japan

3367. Shiotani, M., On the statistic of fluctuations of wind velocity in the lowest atmosphere, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 311–314.

3368. Michelson, I., Ultimate design of high altitude sounding rockets, *Jet Propulsion* **27,** 10, 1107–1108, Oct. 1957.

3369. Kimura, S., Experimental determination of pressure deviations in barometer rooms due to high winds, *J. meteor. Soc. Japan* **35,** 2, 73–77, Apr. 1957.

The pressure deviation from undisturbed ambient value within a barometer room due to high winds is tested in the wind tunnel using two room models, viz., a rectangular parallelepiped box and a circular cylindrical one, both with several perforations on the walls simulating the actual observation state. It is found that it is hardly possible to correct the pressure deviations in an ordinary barometer room, because they show so great variety.

From author's summary

Marine Engineering Problems

(See also Revs. 2992, 3006, 3361)

Book—3370. Czwalina, A., The mechanics of floating bodies [Die Mechanik des schwimmenden Korpers], Leipzig, Geest & Portig K.-G., 1956, 129 pp. DM 12.00.

Continuing the work of Archimedes, author determines explicitly the equilibrium positions for floating bodies of a large variety of shapes, such as circular cylinders, cones, tetrahedrons, segments of ellipsoids. The treatment is detailed and completely elementary. Periods of oscillations about the equilibrium position (neglecting motion of the liquid) are given. Reviewer believes that the value of the book would have been enhanced if at least complete exposition of the classical results of Bouguer and Dupin had been included. F. John, USA

3371. Kan, S., Shiba, H., Tsuchida, K., and Yokoo, K., Effect of fouling of a ship's hull and propeller upon propulsive performance, *Inter. Shipbldg. Progr.* **5,** 41, 15–34, Jan. 1958.

3372. Charpentier, H., An analysis of the cavitation of propellers, *Inter. Shipbldg. Progr.* **5,** 41, 3–14, Jan. 1958.

3373. Argyriadis, D. A., Modern tug design with particular emphasis on propeller design, maneuverability, and endurance, Soc. nav. Arch. mar. Engr., Prepr. no. 7, Nov. 1957.

3374. Blackwell, R. E., and Goodrich, G. J., Model experiments on a series of 0.70 block coefficient forms, Part I. The effect on resistance and propulsion of variations in LCB position; Part II. The effect on resistance of variations in breadth-draught ratio and length-displacement ratio, *Trans. Instn. nav. Arch. Lond.* **99,** 3 (part II), 367–445, July 1957.

3375. Nebesnov, V. I., An investigation of the dynamics of marine propelling machinery (in Russian), *Nauch. tr. Odessk. vysh. morekhod. uch-shcha* no. 1, 3–37, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7497.

An attempt is made to analyze the transitional processes in the motion of the mechanical system formed by the ship's hull, screw propeller(s), hydraulic clutch(es), and propelling machinery. The equations of motion are linearized on the assumption that the variations in the parameters determining the motion of the ship are sufficiently small.

Applying certain assumptions, the system of equations is resolved into two independent parts, of which one refers to the definition of the maneuverability of the ships as characterized by the drift angle, turning speed and course angle of the ship, while the other relates to the operating constants of the propelling machinery as characterized by the number of revolutions per minute and propeller thrust (or horsepower) of the engines.

In the presence of known laws of disturbance, the solution of these equations furnishes a number of conclusions of practical significance. In addition to determining the laws of change of the parameters of motion of the ship, these equations enable investigation of the change in the power distributed to the ship's propellers when maneuvering.

In the case of twin-screw ships, the power of the inboard engine with reference to the turning circle decreases more considerably. The quicker the rudder is put over to a given angle, the more rapid is the fall in number of revolutions, and, therefore, the output of the engine.

The equations obtained are illustrated by a practical calculation, confirming their qualitative agreement with the general physical picture of events. A. N. Shmyrev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3376. Leehey, P., and Steele, J. M., Jr., Experimental and theoretical studies of hydrofoil configurations in regular waves, *David Taylor Mod. Basin Rep.* 1140, vi + 37 pp., Oct. 1957.

Experimental results of amplitudes and phase lag of heave and pitch motions imposed by waves upon a hydrofoil craft with various area stabilized Vee and Flat-Hydrofoil configurations were obtained and correlated with theoretical responses computed by Weinblum's theory. While predictions of the linearized theory were found to be qualitatively correct, measured amplitudes mostly were smaller than theoretical. A mid-foil between tandem Vee foils effectively cancelled heave response to following seas as wave lengths approximated the over-all foil spacing.

J. R. Weske, USA

3377. Stuckler, B., Another contribution to theory of the movement of rolling vehicles (in German), *Ing.-Arch.* **25,** 4, 244–254, June 1957.

3378. Jasper, N. H., and Brooks, R. L., Sea tests of the USCGC Unimak, II: Statistical presentation of the motions, hull bending moments, and slamming pressures for ships of the AVP type, *David W. Taylor Mod. Basin Rep.* 977, iv + 43 pp., Apr. 1957.

3379. Bazilevsky, A., The influence of ship's speed on lateral stability and rolling (in Russian), *Mor. Flot.* no. 1, 23–25, 1956; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7491.

Results are presented of experiments with two ship models for determining their lateral stability and resistance to rolling in motion. The experiments have shown that the influence of the speed of the ship on steadiness requires consideration when assessing the stability of relatively high-speed vessels. Data have been obtained on the change in resistance to rolling when under way. An important relationship has been discovered between ship speed and the value of the moment of inertia of associated masses.

A. A. Kostyukov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3380. Reinberg, E. S., The development of a method for determining the thrust horsepower of a moving ship and tests with the TPU-1 instrument on board the icebreaker "Ilya Muromets" (in Russian), *Trudi Leningr. Korablestroit. in-ta* no 15, 109–120, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7506.

A thrust-measuring instrument is described for determining the thrust horsepower developed by a screw propeller and a ship in motion. The action of the instrument is based on teasometer measurement of the strains in the thrust bearing, linearly and singly depending on the thrust horsepower. The tests of the instrument under service conditions in the icebreaker "Ilya Muromets" showed the feasibility of its steady working with a degree of error not exceeding 5% of the measured quantity.

S. N. Blagoveshchenskii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3381. Bykov, V. M., The dynamic heeling of a towed ship by jerking of the tow rope (in Russian), *Trudi Tallinsk. politekhn. in-ta* **A** no. 61, 17–26, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7494.

The equations of motion of the towing and the towed ship under the action of the tow rope pull are examined. The phenomenon of jerking (sudden pull of the tow rope) is equated to the phenomenon of an impact on the assumption that the tow rope represents a flexible and inextensible filament lacking mass. It is demonstrated that the calculated values of the angle of heel after jerking agree well with the experimental data. A method is presented for finding the limiting jerking velocity, i.e., the velocity corresponding to the maximum permissible angle of heel. A. A. Kostyukov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3382. Amirikian, A., Analysis and design of floating drydocks, Soc. nav. Arch. mar. Engrs., Prepr. no. 6, 44 pp. 1957.

With the objective of furnishing helpful data and guides on the design of floating drydocks, a comprehensive treatment of the subject is presented. In the development of the design, use is made first of the conventional approach, then a detailed discussion is given of the most advanced concepts of analysis. Arrangements and framing are given in considerable detail not only for steel-framed docks but also for those of concrete and timber. In order to simplify the analytical work, general expressions are derived for computing dock stresses under various conditions of loading at sea and in docking of ships. Further design aids are provided in the form of supplementary design tables and charts, including a set for coefficients of moments and shears in the dock pontoon,

which is considered as an elastic cellular slab supporting the ship loading. From author's summary

3383. Davis, A. W., Marine reduction gearing (The twenty-eighth Thomas Lowe Gray lecture), *Proc. Instn. mech. Engrs.* **170,** 16, 477–498, 1956.

3384. Markey, M. F., and Carpini, T. D., Rough-water impact-load investigation of a chine-immersed V-bottom model having a dead-rise angle of 10°, *NACA TN* 4123, 13 pp. + 1 table + 18 figs., Oct. 1957.

A hydrodynamic rough-water impact-loads investigation of a fixed-trim V-bottom float with a beam-loading coefficient of 5.78 and dead-rise angle of 10° was made at the Langley impact basin. The size of the waves varied from approximately 10 to 60 feet in length and 1 to 2 feet in height. Time histories were obtained showing the position of the model relative to the wave throughout the impact, and typical examples are presented. The load coefficient was found to vary primarily with the slope of the impacting wave. From authors' summary

3385. Golovato, P., A study of the forces and moments on a heaving surface ship, *David Taylor Mod. Basin Rep.* 1074, ii + 35 pp., Sept. 1957.

A surface ship model, symmetrical and having mathematical lines according to Weinblum, was oscillated in still water while supported on a stiff force balance. Amplitude of oscillation could be preset and resulting lift force, drag force, and pitching moment about the center of the model were measured. Influence of forward speed, frequency and amplitude of oscillation were investigated.

Added mass and damping of ship motion were determined as well as pitching moments due to heaving velocity and acceleration.

The six-component strain-gage force balance was attached to bottom of an oscillating strut performing simple harmonic heaving oscillations. Difference in motion between model and strut, due to elasticity of balance, was considered in analyses.

Force coefficients from test are given a physical explanation: Damping force is proportional to frequency, and leads buoyancy force by 90 deg, while inertia force is proportional to frequency in second power and leads buoyancy force by 180 deg. As frequency increases, inertia force increases and cancels part of buoyancy force. When the two are equal, the total force is at its minimum, phase angle is 90 deg, and pure damping force is recorded. As frequency increases, the total force, being essentially inertia force, rises sharply and phase approaches 180 deg.

Added mass appears at low frequencies to decrease with increased forward speeds. At higher frequencies for Froude numbers 0, 0.09 and 0.18 there does not appear to be any variation with speed.

Due to mass unbalance in model, phase angle between pitching moment and displacement was different when running tests east and west. Unbalance was found equal to a weight of 32 pounds at an arm of 1 ft. Weight of model was about 80 pounds and length 136 inches.

Comparisons are made between various theoretical prediction procedures and the obtained experimental results.

Significance of observed nonlinear damping forces is discussed.

E. Steneroth, Sweden

3386. Bailey, H. H., Principles of self-contained navigation, *Aero. Engng. Rev.* **16,** 8, 68–73, Aug. 1957.

3387. Faddeyev, Yu. I., An approximate method of determining the natural frequency of oscillation of a ship from the shape of the curve of static stability (in Russian), *Trudi Leningr. Korablestroit. in-ta* no. 15, 53–61, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7492.

The problem is examined of determining the period of free oscillation (free roll) of a ship in still water, regarded as a solid body, taking into account the shape of the curve of static stability. An assumption is made that the influence of the resisting forces on the value of the period of roll of the ship is negligible; author then applies the so-called biharmonic approximation for the angle of heel when, after one integrating the differential equation of the problem, the approximate relationship is found for determining the period of free oscillation (free roll) of the system. The method applied is essentially energetic, founded on solving the equation of work of the moments of forces acting on the ship in rolling. The application of the method described is illustrated by numerical examples for two ships, whose stability diagrams are presented in the form of analytical relationships permitting of rigorous solution by complete elliptical integrals of the first kind. Comparison of calculated results shows that the error of the suggested method does not exceed 4%. Author observes, in this regard, that calculation by this approximation formula is less laborious than when using the method recently suggested by G. E. Pavlenko.

N. N. Babaev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

3388. Schade, H. A., Notes on the primary strength calculation, Soc. nav. Arch. mar. Engr., Prepr. no. 1, 11 pp., Nov. 1957.

The purpose of the paper is to examine several possible refinements which may be useful in the primary strength calculations of the ship's girder in special circumstances. The effect of transverse bulkheads on a distribution of longitudinal stress is normally ignored. The effect is the result of the fact that a considerable fraction of the vertical loads represented by weights and hydraulic pressures are transmitted to the ship's sides by the bulkheads as concentrated loads. A simple formula which makes it possible to estimate such effects without cumbersome calculation is developed. Transverse framing also exerts a secondary effect on longitudinal stresses owing to the Poisson's ratio or lateral contraction. The effect is normally small, but it can easily be estimated. Stresses resulting from torsional moments applied to the ship's girder become important when hatch sizes are large since, in this case, secondary longitudinal stresses develop which augment the bending stresses. A practical system of estimating such stresses is given with an example. The use of a vertical-wave-front concept to estimate the upper boundaries of bending moments to which the ship could ever be subject is proposed. Calculations have been made for the Mariner type and for a simplified geometrical model, and it is shown how to use such calculations to determine this upper boundary of bending moment.

From author's summary

3389. Chapman, J. C., and Slatford, Jean E., Bending of plating with widely-spaced stiffeners, *Shipbuilder* **64,** 588, 191–193, Apr. 1957.

3390. Milton, J. H., Marine machinery break-downs, *N. E. Cst. Instn. Engrs. Ship. Trans.* **73,** 7, 369–379 + 40 figs, May/June 1957.

Books Received for Review

BELLMAN, R. E., GLICKSBERG, I., AND GROSS, O. A., Some aspects of the mathematical theory of control processes, Santa Monica, California, The Rand Corp., 1958, xix + 244 pp. (Paper-bound)

BICKEL, E., Die metallischen Werkstoffe des Maschinenbaues, second fully revised edition, Berlin, Springer-Verlag, 1958, xii + 439 pp. DM 37.50.

BOOLE, G., Calculus of finite differences, fourth edition, New York, Chelsea Publishing Company, 1958, viii + 336 pp. $4.95.

COOPER, S. A., Concise international dictionary of mechanics and geology, English-French-German-Spanish, New York, Philosophical Library, 1949, viii + 400 pp. $6.00.

GRUSS, G., Variations-rechnung, Heidelberg, Quelle & Meyer, vii + 282 pp. DM 14.00.

IHRIG, D., Beszamolo a vizgazdalkodasi tudomanyos kutato intezet 1956, evi munkajarol, Budapest, Muszaki Konyvkiado, 1957, 296 pp.

MOSONYI, E., Water power development. Vol. I: Low-head power plants, Budapest, Publishing House of the Hungarian Academy of Sciences, 1957, 908 pp.

PATTANTYUS, G. A., Gepeszeti lengestan—lengesi folyamatok a muszaki gyakorlatban, Budapest, Akademiai Kiado, 1952, 264 pp.

PATTANTYUS, G. A., A gepek uzemtana, seventh edition, Budapest, Tankonyvkiado, 1956, iv + 461 pp.

RIEGELS, F. W., Aerodynamische profile, Munchen, R. Oldenbourg, 1958, 278 pp.

SALMON, G., A treatise on the analytic geometry of three dimensions, Vol. I, seventh edition, New York, Chelsea Publishing Company, 1927, xxiv + 470 pp.

SOO, S. L., Thermodynamics of engineering science, New York, Prentice-Hall, Inc., 1958, xv + 620 pp. $9.50.

VON MISES, R., Applied mathematics and mechanics, Vol. III: Mathematical theory of compressible fluid flow, New York, Academic Press Inc., xiii + 514 pp. $15.00.

ZYPKIN, J. S., Theorie der Relaissysteme der automatischen Regelung, Munchen, R., Oldenbourg, 1958, 472 pp.

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